POWER

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Sane Progressiveness

THE world stands aside for the man who knows where he is going—and how to get there.

The driver who gets to his destination in the fewest hours is not the speeder who makes fifty-mile-an-hour spurts and then spends more time than he has made looking up directions. It is not the fellow with the speedy but neglected car, delayed by long halts at service stations, by roadside wrestles with busted tires, or by awkward skids into inextricable positions, who makes the most headway.

The fellow who gets there on time, or in the least time, is the fellow who knows the road, and is not led off by the alluring speedway or the apparent short cut, beset by hills and ruts and difficulties that do not show on the map.

There are a lot of conditions, not only in engineering but in life generally, where the present road, the present way of doing things, does not lead most directly to the desired end. Other and more direct ways are apparent, but those who try them often find that they would have done better to stay on the safe and sane and traveled route.

This does not mean that the shorter route should not be developed, but that the effort should be directed to making it the highway of progress, to removing its difficulties and making it recognizable as the best as well as the most direct way.

It does not mean, either, that the newer ways should not be investigated. Improvements and developments are constantly going on in engineering as well as in roads. The man who pins his faith to a six-year-old Blue Book, or to the engineering which he learned years ago and has practiced ever since, and does not keep informed of the newer and better ways and methods that are being constantly opened and developed will soon find himself outdistanced by the better informed.

The true progressive is filled with an overpowering sense of how things ought to be, but tempers his impatience to get them so with a consideration of the conditions which make it impossible to do it all at once.

F. R. Low

Pouring and Fitting Babbitt Linings*

By A. HOYT LEVY

Although an old subject, babbitting bearings is by no means a simple one; each step must be well understood and properly executed. This article tells of the nature of babbitt metals, how to renew linings, and describes some bearing troubles as well as their causes.

THE various metals for bearings, which are spoken of as babbitt metals, do not, in themselves, constitute an invention of Isaac Babbitt. The application of a special metal for the lining of a journal box or bearing, which constituted a construction and did not include a special metal composition, was patented in 1839. In 1842 the importance of this invention was evidenced by an act of Congress granting the sum of $20,000 for the use of this patent journal box in American warships. Progress during the last ten or twenty years has been very rapid in the development of metals for lining bearings.

Strength and toughness are two important factors in babbitt metal. A strong metal may be hard in character, while a tough metal is ductile. The former

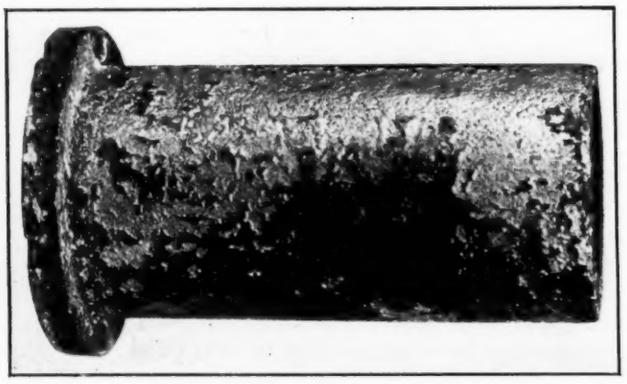

FIG. 1—SURFACE OF BRONZE BEARING BOX EATEN AWAY WHEN BEING TINNED

will carry a heavier load and, ordinarily, at a higher coefficient of friction than the tough metal. Where the load is accompanied by shocks, jolts or vibrations, the strong, hard metal will be likely to crystallize and break up, while the tough, ductile metal will withstand shocks with but little effect. This may be compared to a block made of stone, representing the hard, strong babbitt, and one of rubber, representing the ductile property. Stone may be harder and stronger than rubber, yet more easily shattered by shocks.

In general, the best oil to use for lubrication of a bearing is the lightest grade that can hold a firm film under the operating speed and pressure. When the speed is low, it may not be possible for the shaft to carry the lubricant completely around and keep the oil film intact. Hence, the slower the speed the heavier should be the viscosity of the oil. For very high speeds the oil should be of a correspondingly light viscosity. More lubrication is required for a hard metal, on account of the greater coefficient of friction, than in the case of a soft, ductile metal. Grease is used as a lubricant, by preference, for heavy-pressure machinery.

In making or selecting babbitts, it must be remembered that the formula may be strictly adhered to and yet the product lack a great amount of the desired qualities which are expected and should be present. Babbitts made from scrap metals or from remelted babbitts, do not wear as long as those made from prime virgin metals. Scrap metal should therefore be avoided. Care should be taken in mixing the alloys so that the proper homogeneity may result. This may require many hours with the various precautions for mixing as herein described. On the other hand, if the ingredients are melted and almost immediately poured in the molds, the babbitt may carry hard points or soft spots and become brittle and crystallize in service.

In the interest of economy as well as utility, babbitt linings should be as thin as possible. Where the babbitt requires a high pouring temperature, it is difficult to cast a solid, thin lining, because such babbitts set quickly. Hence the importance of using a metal with as low a pouring temperature as conditions and service will permit.

Where a free-flowing, low-temperature metal may be used, a thin lining will give as long, or longer, service as will a heavier. The reason is that the bronze or iron backing gives the thin lining a rigidity that it does not give the thicker lining.

The important steps in babbitting a bearing are enumerated in Table I.

TABLE I—IMPORTANT STEPS IN BABBITTING A BEARING

1. Clean the melting-pot and ladles.	6. Pour the babbitt.
2. Clean the shell.	7. Peen the babbitt.
3. Tin the shell.	8. Cool the bearing.
4. Cut anchor-holes.	9. Repair small blow-holes.
5. Heat the shell and mandrel.	10. Grooving.
	11. Aligning.

The bearing shells should be free from accumulated dirt and residue of the previous casting. Burn them out, or wash with gasoline, following with lye water. This applies especially to the shell, which frequently contains dirt, oil, grease and rust. Only gasoline or fire can properly clean a shell. If you use lye water, be careful and don't let it burn your hands. Better wear rubber gloves.

Tinning and anchoring are most essential in order that the babbitt lining should adhere firmly to the shell. A loose lining is liable to crack; if it does not crack, its motion will create a suction that will draw away the oil film and so heat the bearing. To fasten the babbitt lining to the backing, the shell should be tinned, or the lining should be anchored, preferably both.

It is quite difficult to tin a cast-iron shell. Bronze shells, however, are tinned readily. By tinning is meant the covering of the contact surface of the shell with a thin coating of solder, which will bind the babbitt lining to the shell. The steps for tinning are as follows: (1) Cover the parts that are not to be tinned, with a light coat of red clay thinned with water; (2) when thoroughly dry, swab the part that is to be tinned, with

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muriatic acid; (3) dip the shell into a pot of solder made of 50 per cent tin and 50 per cent lead and when the shell is heated to a point where the solder runs off, take it out of the pot and let the solder set; (4) swab it a second time with muriatic acid; (5) dip it again into the pot of solder, withdraw and proceed immediately with the pouring. Some master mechanics

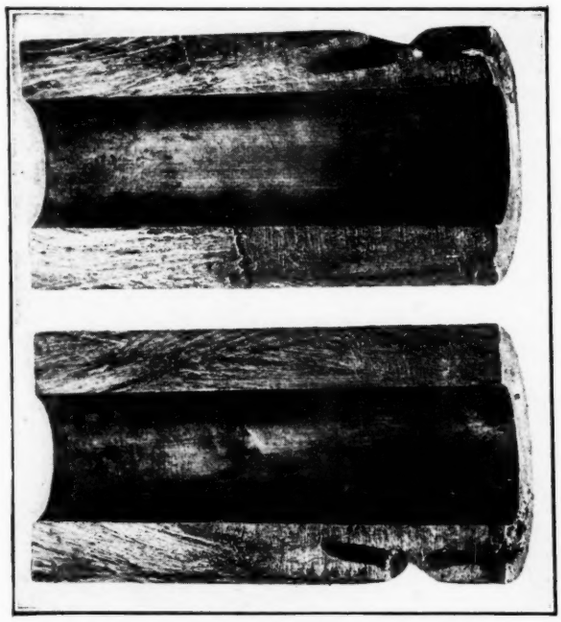


FIG. 2—HOLES IN BABBITT CAUSED BY INSUFFICIENT POURING

prefer to tin by heating the shell on the outside with a blow-torch, meanwhile sprinkling the surface with sal ammoniac and rubbing a solder stick on the inside.

Where the lining is to be anchored, wedge-shaped notches are cut into the shell along the edges. If the shell is already notched, see that the holes are thoroughly clean before you pour the babbitt. Make sure that they carry no metal from the previous lining. When the babbitt is poured, it fills the notches, and when set, the lining becomes firmly dovetailed to the shell. A standard anchor 0.5 in. deep should be about 1.5 in. at its wider end. A 6-in. diameter shaft should have an anchor about $\frac{3}{8}$ in. at the narrow end; the anchor of a 24-in. diameter shaft should be about $\frac{3}{4}$ in. at the narrow end with a taper of about 30 deg. On large bearings some of the anchorages may run from end to end.

Heat the shell and mandrel as babbitt poured into a cold iron shell or against a cold mandrel, will chill and make blowholes. It is important, therefore, to heat both iron shell and mandrel just before the pouring. This may be accomplished with a torch. The mandrel should be heated to about 250 deg. F. when babbitting a tinned bronze shell, and about 500 deg. F. when babbitting an iron shell. Or the mandrel may be heated and plunged into a solution of clay thinned with water. This will give it a light coat of clay and keep the babbitt from sticking to it. Iron shells should be heated to about 500 deg. Tinned bronze shells should not be heated; they should be poured immediately upon application of the second coat of solder. When pouring a solid bearing, smoke the mandrel or cover it with paper to facilitate its removal after the babbitt has set.

Pour the babbitt, keeping the metal stirred, using a ladle, mouth down, and stirring with an elliptical movement from the bottom up, to all parts of the pot. Do not bring the ladle above the surface when stirring, as this will cause the metal to splash, and splashing creates dross. Where the babbitt is not homogeneously alloyed, the stirring will tend to keep it from segregating. This action also keeps all the metal in the pot at an even temperature.

Many faulty bearings are caused by pouring the metal at too high or too low a heat. If the metal is too cold, it pours thick and heavy and the casting will set before it can fasten itself to the shell. If it is poured too hot, the casting will be loose-grained and will break up under impact. There is a "right" pouring temperature for every babbitt, and users should ascertain this from the manufacturers of their metal.

Bear in mind that the pouring temperature does not mean the heat of the metal in the pot. It means the heat of the metal in the ladle as it is being poured. For this reason the pouring of bearings should be done in close proximity to the melting pot. It does not take long for a metal to drop 100 deg. after it is dipped out from the pot, so that when a bearing is poured at a distance from the pot, the drop in temperature is usually enough to affect its casting quality.

Where conditions are such that it becomes absolutely necessary to carry the molten metal a distance, an allowance may be made by bringing the metal in the pot to a higher heat than its proper pouring temperature. This, however, should not be resorted to except where necessary, because a metal once overheated, even when

FIG. 3—CRANKPIN LINER FAILURE DUE TO OIL IN BOX WHEN POURED

brought down to the lower temperature, becomes less capable to withstand impact and wear.

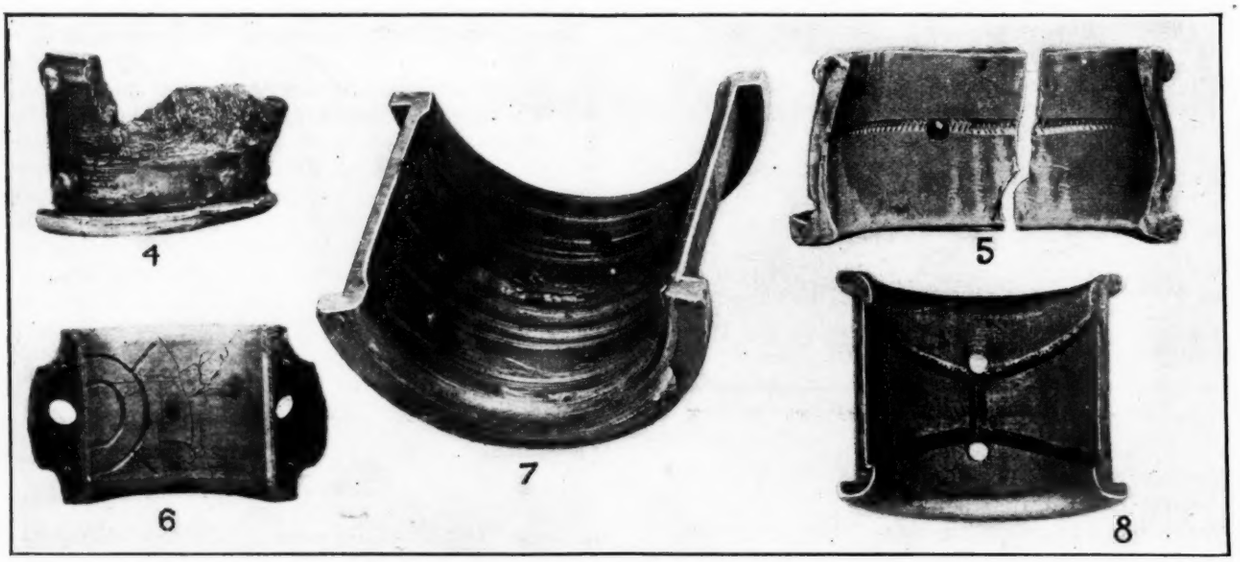
The babbitt in the pot should be brought up to a heat about 50 deg. higher than its pouring temperature. Some babbitts require a higher heat for pouring than others. Ascertain the temperature at which your babbitt should be poured and try to hold to that temperature when pouring. The reason we say the babbitt in the pot should be brought to a heat about 50 deg.

higher than the pouring temperature is because it will lose about that much heat in the interval between the dipping and the pouring.

Do *not overheat* your metal more than 50 deg. A highly heated babbitt will pour a loose-grained, brittle casting which may not be able to sustain its load. As stated before, if a babbitt is once overheated, it loses a tensility which can never be recovered. If you have no thermometer, you may gage the heat with a pine stick. Such a stick, when plunged into molten babbitt, will char at about 650 deg. It is safest, however, to work with a thermometer and so gage your heat to a definite degree.

Where the bearing is in two or more sections, pour each section separately in this manner: Heat the box; line it up on a level base; take two pieces of sheet metal that have been cut to the radius of the box; with a C-clamp, fasten them to each side of the section, the sheet-metal extending above the edge to about the height of what the thickness of the liner will make it. Clay the edges at the base. Block the heated mandrel in place. Pour slowly at first, to expel the air from the bottom, then pour swiftly in a steady stream along the length of the mandrel, keeping back the dross with a flat stick. As the box fills, slow up a little but continue to pour until the metal runs over.

Babbitting under difficulties is sometimes necessary. The metal is melted over a wood fire in the open air and the usual shop facilities are lacking. In such cases the metal is frequently melted in a pot that is set into or over the fire, and when melted, it is dipped out with a small ladle and poured. Usually, this method requires a dozen or more ladlefuls for a bearing, so that the resultant bearing is made up of layers of babbitt and in danger of cracking at any of the several seams. A good way to overcome this is to use a lipped pot for the melting. Near-by, have a beam from which hangs a chain and hook that will hold the kettle just high enough to pour into the box without splashing, when tilted. When the metal is melted and ready for pouring, it is carried over and hung to the chain. Then, with a pair of tongs, it is tilted and poured at once into the box without stopping. All arrangements should be made in advance so that the metal will not cool between the time it is taken from the fire and the time it is poured.



FIGS. 4-8—APPEARANCES OF BABBITT LINERS FROM WHICH WORKING CONDITIONS WERE ANALYZED

Fig. 4—New babbitt poured over old babbitt leaves crack through which lubrication escapes. Fig. 5—Bad grooving in automobile connecting-rod liner contributes to the failure of the bearing. Fig. 6—Steam-engine crankpin bearing cracked on account of shell having been underheated, when pouring. Fig. 7—Connecting rod bearing of motor truck. Observation showed a skin of steel practically welded to the babbitt, which indicated a bone-dry condition when the engine was started. It was found that the mechanic had forgotten to oil up properly before starting the engine. Fig. 8—Example of good grooving design of automobile connecting rod-bearing lubricated by the splash method. Note that the grooves are run through almost to the end of the bearing.

Grain of the Babbitt in the Direction of Revolution

It will be observed that by pouring as herein described, the grain of the metal runs in the direction of the shaft's revolution. Except in the case of a one-piece bearing that must, of necessity, be poured in a vertical position, bearings should always be horizontally poured.

Peen while still warm. This will, to some extent, compress the metal. But it is of equal importance that if the lining is not secure to the back, the condition will be detected by the sound when the hammer peens over a hollow part.

Cool the bearing, because the denser the liner the more durable it will be. You can increase the density by cooling quickly while the metal is still molten or semi-molten. This may be done by applying cold water to the bearing shell with a sprinkler or hose, cooling from the bottom to the top. Or place the bearing shell in a container of some sort and pour cold water in the container. This will cool the bearing quickly from the bottom upward.

Repair small blowholes, although there really should be none in a properly poured bearing. Where the blowholes are small, it is not necessary to repour the bearing. Small blowholes, or pin-holes, may be filled in with babbitt and smoothed down with a soldering iron.

Oil grooves may be termed auxiliary reservoirs. Their purpose is to help in the proper distribution of the oil over the entire bearing surface. They also serve to return for re-use, the oil that otherwise would run out at the ends of the bearing.

The grooves should be cut shallow with the receding

edges rounded off. A sharp edge on a groove will wipe away the oil. Where the two halves meet, groove away the inside edges on both halves, stopping short of the ends. The grooves so formed should likewise be rounded off. These additional recesses will serve to draw in the oil and relieve the side pressure on the journal.

In bearings that are lubricated by the splash method, such as automobile bearings, the grooves should run clear through to the edges and should be somewhat deeper at the edges to permit the easy access of the oil. A good grooving design for these bearings is the "X" design or the one shown in Fig. 8.

In the wearing down of a bearing the rounded edges of the grooves may wear away and become sharp. Examine the grooves when you can, and if the edges have become sharp, correct the defect at once.

To get a true and accurate fit, the bearing surface should be scraped down until it is perfectly seated over its entire wearing area. To scrape a bearing, rub the journal surface thoroughly with Prussian blue, then place the bearing on the journal and rub the surfaces together by rotating lightly. Remove and scrape the high points until the fit is absolutely perfect.

If the bearing heats and you suspect that it may be due to faulty alignment, you may ascertain this definitely by taking apart the bearing. Bright spots on the bearing will tell the story. Scrape these and you will get relief.

TABLE II—A LIST OF CAUSES FOR HOT BEARINGS

1. Babbitt has too high a coefficient of friction.
2. Interruption in oil.
3. Oil impure or of wrong viscosity.
4. Insufficient clearance or too much clearance.
5. Faulty grooving.
6. Faulty alignment.
7. Faulty fitting.
8. Excessive pull.
9. Grit laden or hot atmosphere.
10. Excessive compression.
11. Tightened belt.
12. Faulty distribution of oil.
13. Insufficient cushioning in steam cylinder of steam engine.
14. Feed-pipe too small.
15. Bearings too small for its load.
16. Lowering of oil level in reservoir of ring-oiled bearing.
17. Oil reservoir too small.
18. Glazed lubricating pad.
19. Congealed oil.
20. Bearing knocked out of line.
21. Sprung shaft.
22. Shaft magnetized.

Should the shaft be out of alignment and it is not feasible at the time to correct it, or if the shaft is already scored, do not under any conditions use a hard babbitt. Such a babbitt will heat and score a misaligned shaft. It is better to use a soft, tough metal that will seat itself into the scored surface of the shaft.

After scraping and fitting, the bearing may still have slight inaccuracies. To wear these away, apply a mixture of one-third powdered graphite and two-thirds high fire-test cylinder oil, thoroughly mixed to a medium paste consistency, and run a few hours at about half its maximum speed.

Some of the causes for hot bearings have been discussed. A list is given in Table II. Here we will devote ourselves to emergency remedies. If a small bearing heats up, flood it with kerosene. This will wash away the dirt and grit that may have caused the trouble. Then follow immediately with a copious flow of lubricating oil, as the washing away of the dirt also carries away the oil, which must be promptly replaced.

Bearings have been known to run hot when in a hot atmosphere. If they should happen to be close to a furnace or any other place where they are subject to a direct heat, the excess external heat, added to its own frictional heat, may be sufficient to cause expansion of the shaft and bearings and a consequent seizing. This will be better understood when it is explained that there are a frictional temperature, a bearing temperature and an atmospheric temperature. The frictional temperature remains always unchanged. But for every degree of fluctuation in the temperature of the atmosphere, the temperature of the bearing fluctuates to the same extent, and a rise in the atmospheric temperature, added to the normal bearing temperature, may cause the bearing to expand sufficiently to seize the journal and so heat still further.

Bearing conditions as encountered in actual practice are illustrated in Figs. 1 to 8. In Fig. 1 an armature bronze bearing box was being tinned preparatory to babbitting. When lifted from the pot of melted solder, it was found to be eaten out along the surface. This could not have been done by an acid used in cleaning; an investigation showed that this bronze box contained a high percentage of lead. The latter sweated out on being heated by molten solder.

In pouring babbitt this process should continue until the mold is entirely brimful. In Fig. 2 the pouring was stopped when the mold appeared to be almost full. It was not sufficient to compensate for contraction of the metal. The result was holes and groovings, as shown. The liner in Fig. 3 failed when the steam engine first started up. This was a two-section crankpin bearing, 12 in. in diameter, carrying a very heavy pressure. and was found to be dark in color throughout most of its length except at the ends. The ends were bright, showing that the bearing pressure was carried there instead of at the middle. Several of the anchors had not been filled with babbitt, allowing the ends to work loose. These showed that oil had been present in the box when the babbitt was poured in. Other contributing causes were bearing box not sufficiently heated and a cold mandrel, when pouring.

Troubles encountered in Figs. 4, 5, 6 and 7 are indicated by the captions. Fig. 8 is a good example of a successful liner for automobile crankpin. The grooves should be brought close to the end of the bearing, where splash oiling is used.

Deflection of the spindle is the most frequent cause of vibration in a steam turbine as it may present itself every time the machine is brought to speed. It is usually caused by the sagging or deflection of the shaft between its bearings during periods of rest or by a leaking throttle valve which allows the higher-temperature steam to occupy the upper part of the casing, thereby heating the spindle unequally and causing it to warp. The remedy for these troubles is to turn the spindle to new positions at regular intervals during the off-load periods. In starting the machine the spindle should be rotated as quickly as possible and the steam shut off immediately after it begins to turn. The machine is then sounded and the exposed section of the spindle is inspected for deflection. If everything seems to be in good order, the steam is again turned on and the spindle brought to about 25 per cent speed, being allowed to revolve at this rate for 15 or 20 minutes, which will usually insure smooth running. It is then brought up to operating speed.

Heat Balance Correction—In the article "War Department Turns to Fuel Oil," in the Aug. 28 issue, item 22 in the tabulation of test results and heat balance should have read, "Equivalent evaporation total lb. 397,008" instead of "497,008," as given.

Generator Voltage Regulators—Alternating-Current Type

Why Direct-Current Generator Voltage Regulators Cannot Be Used to Control the Voltage of an Alternating-Current Generator—Operation of Two Types of Voltage Regulators for Alternators

By J. H. ASHBAUGH
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SOME of the early types of alternators had a compound winding which was energized by rectifying the current from series transformers connected in the main armature circuit. This met with success only when the load was of unity power factor for the armature reaction of alternators varies with the power factor, so that it is almost impossible to obtain satisfactory compounding with varying power factors.

The need for an alternating-current regulator was much greater than that for the direct-current regulator. The difficulties encountered were likewise much greater, and considerable time elapsed before the first successful regulator was built. The main difficulty in the solution of the problem was the large inductance in the generator field. This inductance causes the regulators to do what is commonly known as hunting; that is, continually surging the voltage above and below normal and never reaching a stable point.

One of the first attempts toward regulating an alternating-current machine was to connect the main control magnet of the direct-current regulator (as explained in the previous article, July 17 issue) across

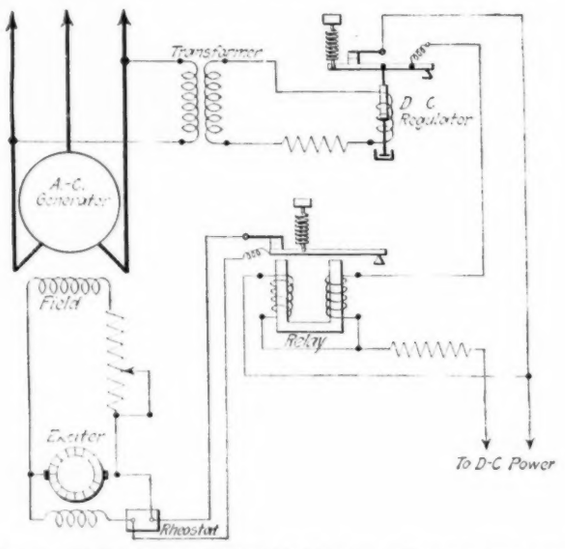


FIG. 1—DIRECT-CURRENT VOLTAGE REGULATOR CONNECTED TO ALTERNATING-CURRENT GENERATOR

the terminals of the alternator, the rheostat shunting relays being connected across the rheostat in the field of the alternator. This system will function, but it is not practical except on very small machines, as the current that the relay contacts are required to handle is prohibitive.

It might appear possible to connect the relay contacts, as in Fig. 1, across the rheostat in the field of the exciter, leaving the main control magnet of the direct-current regulator connected to the alternating-current bus, but this will not operate owing to the

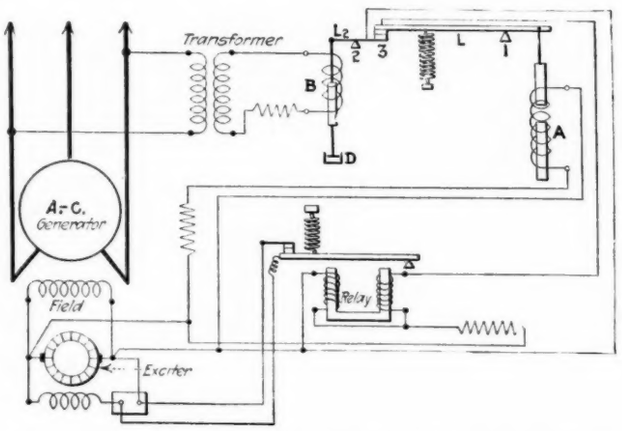


FIG. 2—DIAGRAM OF FIRST SUCCESSFUL TYPE OF TIRRILL VOLTAGE REGULATOR FOR ALTERNATORS

time lag in the system. Analyzing the operation of such a regulator, it is found that if the contacts are closed and the machines are building up, then when normal voltage is reached on the alternator, the main control magnet will pull its core down, thereby opening the main contacts and consequently the relay contacts. The exciter will immediately start to build down, but the alternator's voltage will not stop rising, since the exciter voltage is considerably in excess of the voltage necessary to give the proper field current; that is, the generator-field current lags behind the exciter voltage. The exciter voltage does go considerably higher than actually required inasmuch as, when in the act of building up, it must supply a voltage equal to the field resistance drop plus the inductive drop. This inductive drop is caused by the change in the flux through the field winding. The inductive drop varies directly with the rate at which the exciter builds up, or with the rate at which the generator field current is varied. As a result the alternator's voltage will continue to rise even though the relay contacts are open and the exciter is building down. When the alternator's voltage has been reduced to normal, the exciter's voltage is below normal and the regulator continues to hunt, swinging the voltage above and below normal, but never reaching a point of equilibrium.

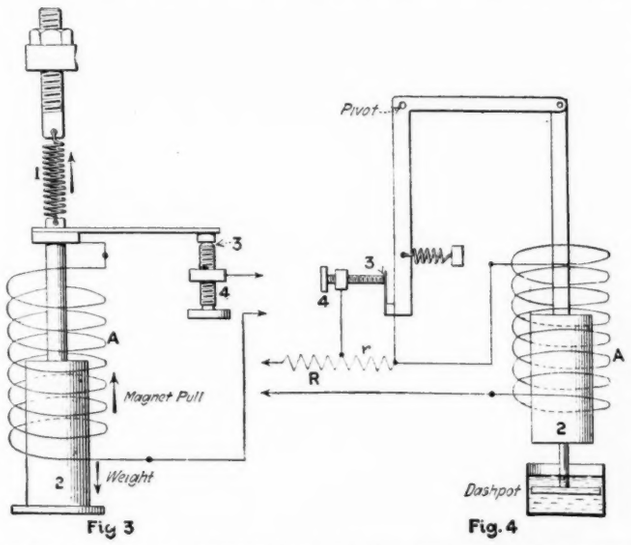
It is evident that the use of the direct-current regulator to control an alternating-current generator is impossible unless some means are provided which will take

into consideration the action of the exciter under these conditions. The first successful regulator, as invented and developed by A. A. Tirrill, made use of a control magnet *A* energized by the exciter voltage, as indicated in Fig. 2. A second magnet *B* was connected to the terminals of the alternator. The lever system was so arranged that the direct-current magnet carried one contact and the alternating-current magnet the other, these being pivoted through the panel at points 1 and 2, thus giving the main contacts 3 a floating action. An increase in either the exciter or the bus voltage tended to open the main contacts. This regulator consists of a complete direct-current regulator, magnet *A* and lever *L*, whose regulated voltage is adjusted in accordance with the alternating-current voltage magnet *B* and lever L_2. A dashpot D is provided on the alternating-voltage magnet to damp out the vibration due to the frequency and prevent this magnet from forcing the exciter voltage too far ahead of the alternator's field current. The fact that the direct-current magnet cannot be maintained sensitive over a much greater range than 1 to 2, or 70 to 140 volts on 125-volt exciters, places a serious limitation on it. This quality is inherent in this type of control magnet.

Requirements of the Voltage Regulator

The poor inherent regulation of alternating-current generators, together with long-distance transmission lines and synchronous condensers, makes it necessary for automatic voltage regulators to be capable of varying the exciter voltage from residual to maximum, in some cases a ratio of 1 to 24. Mr. Tirrill developed a second regulator and eliminated the direct-current control magnet, and made it possible to control the exciter from the residual to the maximum voltage available.

In his second regulator, the direct-current magnet was replaced by an alternating-current vibrating magnet connected directly to the circuit to be regulated. The main control magnet was retained in its former capacity, being connected to the alternating-current circuit to be regulated. The circuit to the rheostat shunting relays can be connected directly to the exciter or supplied by power from any available constant-potential source.



FIGS. 3 AND 4—SCHEMATIC DIAGRAMS OF VIBRATING MAGNET FOR MODERN TYPE VOLTAGE REGULATOR

The distinguishing feature between the first and second regulators is the vibrating magnet in the control element. The action of this magnet is somewhat similar to that of the common electric vibrator, although it has been considerably modified. The elementary electric vibrator, Fig. 3, has its operating coil *A* in series with a set of contacts 3. Core 2 carries one of these contacts, the other one being stationary, and the solenoid action of coil *A* tends to pull the core and its contact up. The weight of the core 2 produces a force in the downward direction and is partly opposed by the pull of spring 1. The magnetic pull, due to coil *A*, added to the spring pull, overcomes this weight, allowing the core to travel upward and contact 3 opens the circuit to coil *A*. When the circuit is opened, the magnetic pull is zero and the core moves down in the coil, until contacts 3 close and core 2 again moves up, and the action previously described is repeated. Thus, the magnet continues to vibrate. It is seen that when the contacts are open the pull is zero, and when closed it is maximum, so that continuous vibration is obtained when the average upward magnetic pull plus the pull of the spring just balances the core weight.

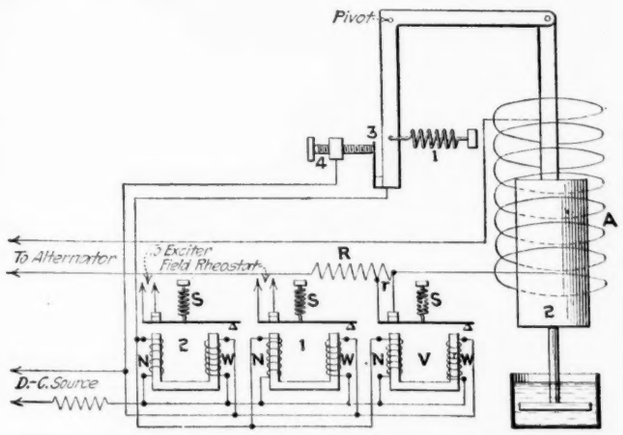


FIG. 5—DIAGRAM OF VOLTAGE REGULATOR EQUIPPED WITH VIBRATING MAGNET

Adjustment of Vibrating Contact

If the contact screw 4, Fig. 3, is moved up to a new position and vibration still remains, the contacts must remain closed for a longer time in order to increase the average upward pull. This is necessary since in moving the contacts the spring tension 1 has been reduced, thus necessitating the magnet pull of coil *A* to increase in direct proportion to the decreased spring tension. From the foregoing it is seen that for every position of the contact 4 within the vibrating range there corresponds a definite time of contact engagement. Likewise, if the voltage on coil *A* changes, the time of contact engagement changes, since the magnetic pull of coil *A* plus the pull of spring 1 must equal the core weight 2; to get the same average pull on a reduced voltage, the contacts 3 must remain closed for a longer period of time. The time of contact engagement in a simple electric vibrator can, therefore, be changed by changing adjusting screw 4. It also, as explained in the foregoing, possesses the ability of automatically changing its time of engagement on a change of voltage. Therefore, it inherently possesses the necessary elements for a voltage regulator.

In the actual regulator the contacts do not completely

open the circuit, but, as shown in Fig. 4, they merely operate across the section r of the external resistance R in series with the magnet coil A. When contacts 3 open the circuit, the pull is not reduced to zero but decreased.

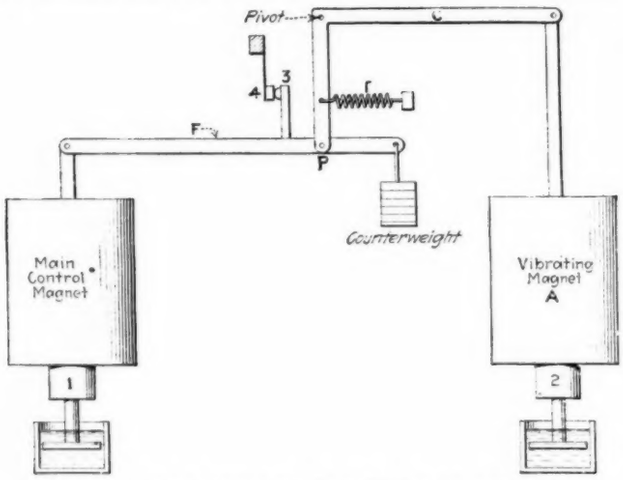


FIG. 6—FLOATING LEVER SYSTEM IN VOLTAGE REGULATOR

The average pull is the difference between the pull with the contacts open and the pull with the contacts closed. The result of this is to make the device more sensitive both to contact adjustment and to variation in line voltage.

The next step in this development was to arrange the contacts so that they could be utilized to short-circuit the exciter field rheostat. It is seen in Fig. 5 that the main contacts are made to open and close the circuit to a group of relays, one of which V short-circuits the resistance r. This latter relay is called the vibrating relay. The main contacts then are not limited to operating only across a section of the resistance in series with the vibrating magnet, but operate a group of relays, thus permitting these relays, 1, 2 and V, Fig. 5, to be utilized to control the exciter voltage by short-circuiting the rheostat in the field circuit of the exciter.

Upon a change in the adjustment of the main contact screw 4, Fig. 5, the vibrating magnet A will change in time of contact engagement, as is the case with the elementary electric vibrator. This will change the time of engagement of the group of relays and will consequently change the time of short-circuit of the exciter field rheostat which determines its effective resistance and will produce a corresponding definite exciter voltage. This means that a change in the adjustment of the contact screw will change the exciter voltage.

Should the adjusting screw be changed in accordance with the variations in the alternating voltage, this device will then regulate to hold the voltage constant. In order to effect this adjustment, another control magnet is used which is connected to the alternating voltage to be regulated. Fig. 6 illustrates the arrangement of the lever system. Referring to this figure it is seen that the vibrating magnet core 2 is connected to a bell-crank lever C. Another lever F called the "floating lever" is pivoted in the lower end of the bell crank at point P, and this lever carries the moving contact 3. The main control magnet core 1 is attached to one end of the floating lever F. Any movement of the main control magnet core will affect the adjustment of the contact 3 with reference to the bell-crank lever C,

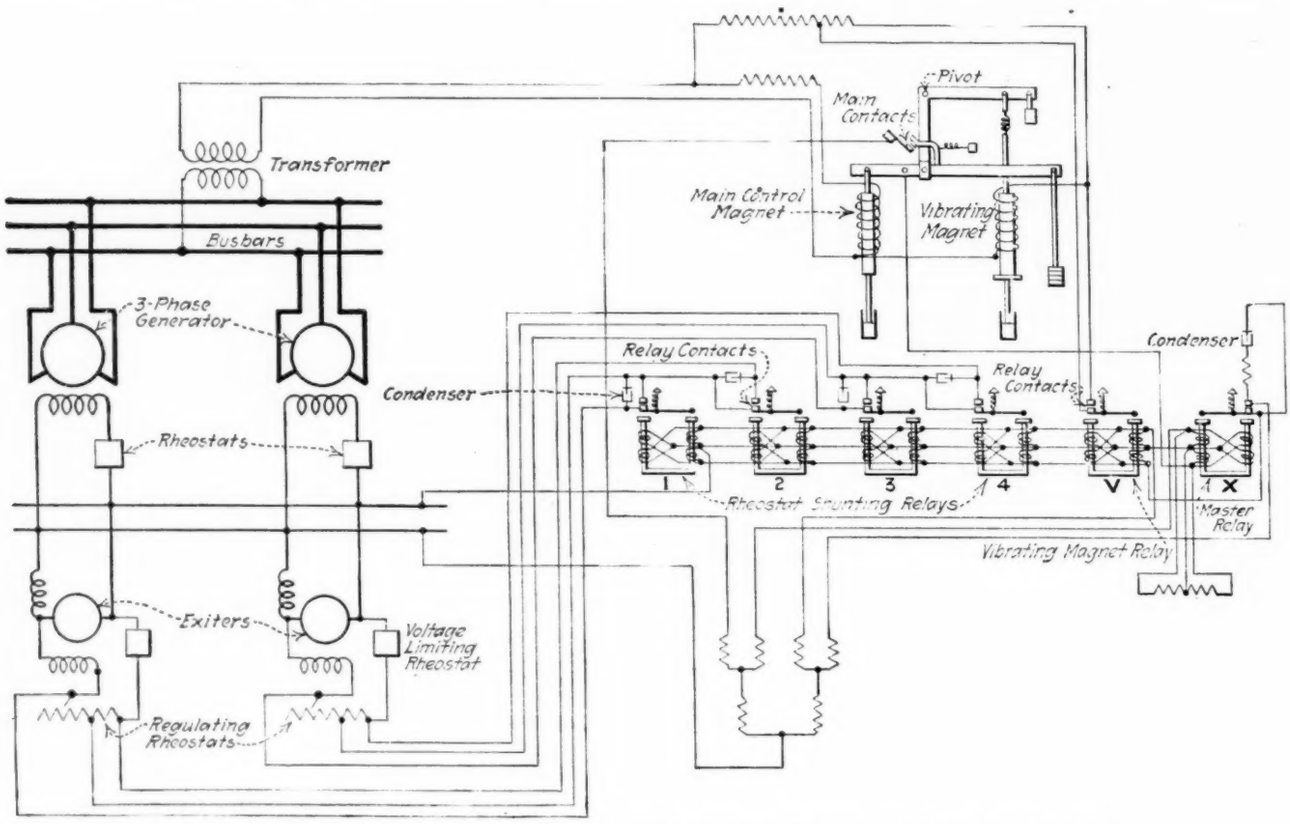


FIG. 7—CONNECTION DIAGRAM OF ALTERNATING-CURRENT VOLTAGE REGULATOR

thereby affecting the spring tension *T* and the time of contact engagement. If the position of this floating lever *F* is changed, the time of contact engagement of contacts 3 and 4 is changed. Consequently, the time of contact engagement of the relays is changed which, in turn, will change the exciter voltage.

If the alternating voltage lowers in value, the core of the main control coil will lower its position, tending to close the contacts 3 and 4. A longer time of contact engagement increases the pull on the vibrating magnet and its core 2 will rise. This increase in the time that the contacts are closed will increase the excited voltage, and consequently the alternating-current voltage, and the system will reach a balance when the alternating voltage is normal in consequence of the

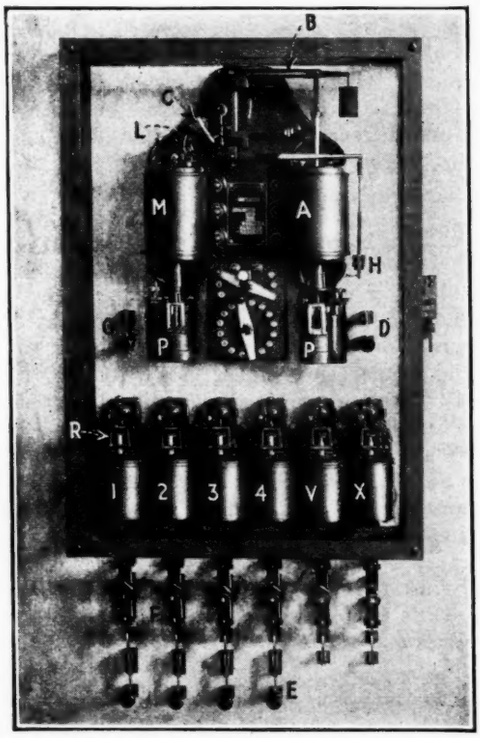


FIG. 8—ALTERNATOR AUTOMATIC VOLTAGE REGULATOR
A, vibrating magnet; B, bell-crank lever; C, main contact; D, direct-current disconnect switch; E, relay-contact disconnect switches; F, reversing switches; H, counterweight; L, floating lever; M, main control magnet coil; P, dashpot; R, relay contacts; V, vibrating relay; X, master relay.

vibrating magnet having raised its core. From no load to full load the main control core will merely lower its position to increase the exciter voltage in order to maintain a constant bus voltage. The main control magnet is so designed that it can have the same pull for various positions of its core 1. This range is limited to a certain travel. Thus it can lower slightly, increasing the time of contact engagement, yet it will balance for the same alternating voltage, or it can rise slightly, decreasing the time that the contacts are closed and still be in balance for the same alternating voltage. This fact permits the regulator to vary the exciter from no load to full load for the same alternating voltage. In the majority of regulating devices, such as governors and other regulators, there is an error in the quantity regulated. The vibrating magnet being very sensitive to variations in line voltage permits it to correct for sudden changes without waiting on the more heavily damped main control magnet.

Both the vibrating and the main control magnets have dashpots. These may be adjusted so as to give the lever system a time constant suitable to that of the machine being regulated; that is, if the machine is small and responds rapidly to changes in exciter voltage, the damping is slight, but if the response is slow, then the damping must be correspondingly greater.

The relays 1 and 2, Fig. 5, are wound differentially, that is, they have two windings. One winding *W* is permanently connected to the bus through the resistor, while the other winding *N* is connected to the bus through the main contacts. If these contacts are closed, the two windings neutralize each other and the spring *S* closes the contacts.

When a large machine is to be controlled, the number of relays required may exceed the capacity of the main contacts. The main contacts 3 are then made to control the master relay *X* shown in Fig. 7. The contacts of relay *X* operate relays 1, 2, 3 and *V*; thus the capacity of the regulator is practically unlimited.

The direct-current power for the relays can be obtained either from the exciter or from some other source. If this power comes from the exciter, it will limit the voltage range through which the exciter can go, since at low voltage there will not be sufficient power to operate them and at extremely high voltage they will have too much current with subsequent damage to the insulation.

The maximum voltage range through which these relays will work is a ratio of 1 to 3 or 45 to 135 volts. However, if some constant-potential source other than the exciter is available, they can be connected to it and the regulator can then vary the exciter from residual to maximum. In this case there are no coils on the regulator operated from the exciter voltage.

From the foregoing it is seen that an alternating-current regulator must have incorporated in it some feature that will prevent hunting. In one device this is accomplished by directly utilizing the action of the exciter, while in the other the inherent characteristic of a vibrating magnet is used. One may have advantages over the other, yet in the final analysis they will both give good regulation when not called upon to exceed the limits that are inherently in the devices.

With all precautions taken, it is still impossible to exclude all air from a steam condenser, and that entering must be continuously and effectively removed to obtain satisfactory results. With the rotative dry vacuum pump one of the most frequent causes of unsatisfactory operation is the clogging up of the valves and port passages in the air cylinder from carbonization of the lubricating oil. When this trouble is encountered, it will be found to be due to using an improper grade of oil and probably an excessive amount. The remedy is to change the kind of oil (a high-grade air-compressor oil is usually suitable) and cut down the amount that is used to the minimum compatible with proper lubrication. Precautions should be taken when operating this type of pump to guard against flooding of the condenser due to stopping of the hotwell pumps or otherwise, as in this case water will be carried over into the dry vacuum pump with serious results. With this type of pump the air entering the condenser system may be easily measured by means of a gasometer attached to the pump discharge; this gives an excellent means of checking up the tightness of the system.

Installing and Operating an Oil-Engine Plant

By V. Morris

Engineers who are in charge of plants in the developed parts of the country little realize the difficulties attendant upon the erection and operation of a mine power plant.

The properties of the American Silver Corporation are in the Mogollon Mountains of New Mexico. Since the

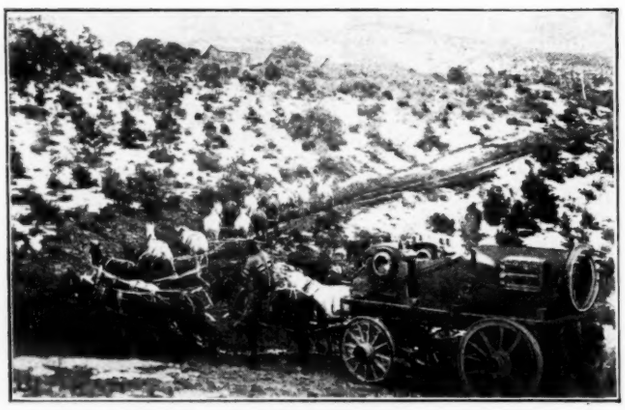


FIG. 1—HAULING ENGINES OVER THE MOUNTAINS

plant is 75 miles from the nearest railroad, the cost of transporting fuel is high and precludes the use of steam power. In view of the acknowledged low fuel consumption of oil engines three 260-hp. and one 180-hp. De La Vergne type FH engines were purchased. One of the larger engines drives a 11x20x16-in. air compressor and a 80-kw. direct-current generator through a contershaft; the compressor supplies air for the mine drills, while the generator furnishes power to the mine hoist. A second of the 260-hp. units is belted to a 150-kw., 480-volt, 60-cycle, three-phase alternator, and the third one is direct-connected to a 187-kw. alternator; both of the generators supply current to the mill motors. The 180-hp. engine is belted to a 100-kw. alternator and is used as a stand-by.

How Transportation Difficulties Were Overcome

The transportation of the machinery was a decidedly hard undertaking. The bedplates weighed seven tons each, while the crankshaft weighed eight tons. These heavy parts were hauled on a wagon, twenty horses being required to pull the wagon up the steep and tortuous trails. The method of making a sharp turn is shown in Fig. 1, from which an inkling of the character of the country and the transportation difficulties may be gained.

The power-plant building is of mill-timber construction and inclosed both roof and sides by corrugated steel sheeting.

Some erectors might hesitate about lifting a seven-ton engine bed with a single chain hoist, but as shown in Fig. 2, this was the method of erection. The plant is equipped with a ten-ton traveling crane, the track of which extends the full length of the building, so that the one frame could be lifted and moved to the desired position. The plant has some unusual features made necessary by the character and location of the mine.

Each engine is supplied with a 500-gal. fuel tank which was immediately outside the building and close to the engine exhaust. In this way the oil is kept warm by heat from the exhaust pipe. In addition to these individual tanks there is a 1,500-gal. tank outside the building, but above ground. Electric heating coils are installed in this tank to heat the oil in cold weather.

The oil is hauled from Silver City, N. M., 75 miles away, and the continuation of supply during the winter is of importance. Often the heavy snows make it impossible to move the oil trucks. Since the monthly fuel consumption is about 176,750 lb., it was deemed advisabe to provide oil storage, and three tanks of 65,000 gal. total capacity were installed at some distance from and somewhat below the plant level. This location eliminates all fire risk.

The engine cooling water, after leaving the cylinders, flows into a concrete hot-well below the floor level. It is then elevated to the cooling tower, Fig. 3, by double-acting back-geared pumps belted from the engine shafts. After passing over the cooling racks, the water drops into the tank from which it flows to the engines under a 25-ft. gravity head. The make-up water comes from mountain springs and carries no scale-forming matter.

Electric Unloader Devised

To overcome heavy peaks and keep the engine carrying the mine load from slowing down, a home-made electric unloader was installed on the mine compressor. The switch controlling the unloader is mounted on the engine governor. When the hoist starts from the lower levels, the acceleration of the hoist results in a very high peak to the engine load, and to reduce the load as much as possible, the compressor is cut out until the hoist gets started. As soon as the hoist starts, the load eases up and the governor releases the switch, allowing the compressor to work again. By this arrangement the engine maintains uniform speed and handles the peaks very nicely.

A 200-gal. tank receives the dirty lubricating oil as it comes from the engines. The oil then goes into the bottom of a 300-gal. tank and flows out at the top to

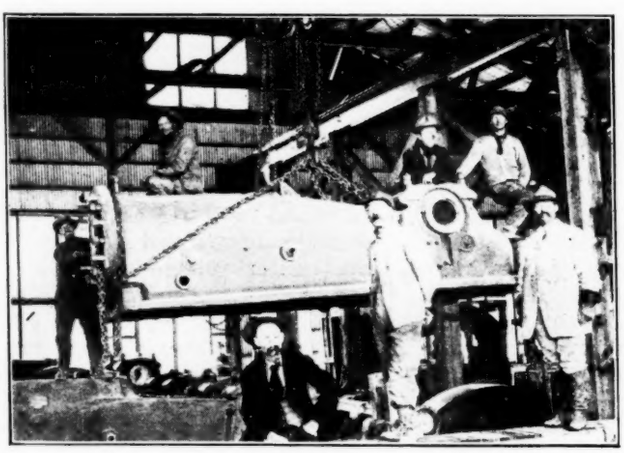


FIG. 2—HANDLING HEAVY ENGINE FRAMES

the bottom of a third, and from the third the oil passes to a pressure tank from which it is raised into an overhead storage tank by compressed air. The tanks have hot water coils in them for heating the oil in order to allow the water and dirt to settle to the bottom.

The system does not clean the oil as well as some of

the patented filters, but it takes out all solids and dirt, so that there has never been any bearing trouble from using it. The filters require little attention, only having to be cleaned twice a year.

The engine pistons are examined periodically, all carbon scraped off, and new rings put in as needed; as a rule, the first two or three need renewing. After eight months' run they are pulled again and examined for wear and general conditions. It has been found that there are no two pistons that will give the same amount of service, some lasting more than three years, while others will not wear a year. As a rule they will give

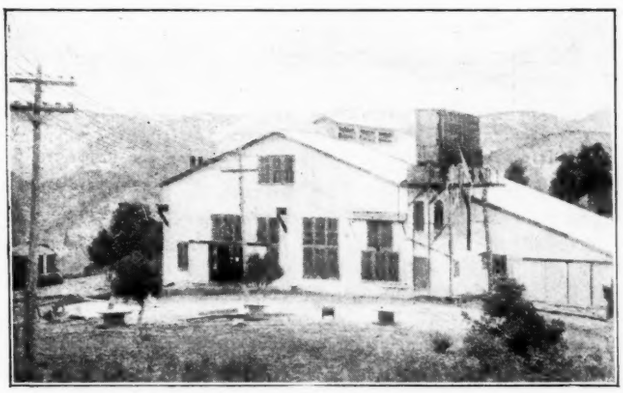


FIG. 3—PLANT BUILDING AND COOLING TOWER

better than twenty-four months' service before the liner needs renewal or reboring.

The engine compressor cylinders and pistons run about eighteen months without any repairs other than new rings in the high-pressure pistons. These rings are renewed about every six months.

Examination and Repairs

The engines are examined every 60 days, the adjustments consisting principally of grinding the exhaust, inlet and all compressor valves. The fuel-oil pump valves are ground every other repair period. Some fuel oils formed carbon on the exhaust-valve seats very quickly, building up anywhere from $\frac{1}{64}$ to $\frac{1}{32}$ in.; then a small piece of the carbon would break off, causing the valve to leak even though the exhaust valve itself would be in good condition. But if allowed to run any length of time in this leaking condition, the hot gases soon cut the valve seat. The only way to save the valve is to grind it as soon as it shows a leak. The policy followed is to shut down and make any repair as soon as it shows up, rather than to run through to some certain inspection date; in that way some accidents have been avoided that might have caused quite a long shutdown. At times, when down to change a spray valve or tighten a piston-pin bearing, loose oil rings on crankpin bearings have been found and repaired, which, if allowed to run until the bearings got hot, would have meant renewing of the bearing.

Exhaust-valve seats get pitted until it takes some time to grind in a good seat; to overcome this difference a turning bar was made. A few turns of this bar will face the seat down to where it only takes a few turns of the valve with grinding compound to get a good bearing. The first cylinder heads that came with the engines had no false valve seats; when the seats wore down or a small crack showed up in the valve seat the head would have to be taken off. But with the boring bar a recess can be turned and the false seat set in it without removing the head.

New exhaust valves are always used on the mill engines until about half of the stock has been worn off; then they are used on the engine pulling the mine load. The load on the two mill engines is practically constant and the valves will get much hotter than on an engine where the load fluctuates as it does on the mine engine. By the change the valve is less likely to break and cause trouble than if run at a high temperature all the time.

It has been found that it is not necessary to change a cylinder head as soon as a fracture develops. That is, if the fracture will take up when hot, which most of them will do, it will pay to nurse it along as long as possible rather than to throw the head away, although it is very unhandy at times to have a head that will leak water into the cylinder as soon as it gets a little cool. The plant has never been able to get a head welded so that it would stand up. There are two heads that for over two years have leaked badly as soon as they cooled off a little, but by reducing the cooling-water flow when the load is light, the operators have been able to use them. When the engine is shut down, water is cut off at once and the relief valve opened to let any water that may have leaked into the cylinder run out. As soon as the engine is started, the load is put on and the crack takes up and causes no trouble.

Testing Resistance to Emulsification

Resistance to emulsification is the quality of the oil by which it is able to separate itself from water after being mechanically mixed. Tests in general include a method of mixing oil and water or other emulsifying agents and allowing them to stand for a certain period, with observations of the separating action being taken and recorded. It is desirable to prevent a high temperature in the mixing process, such as would be caused by the use of steam for agitation of the liquid.

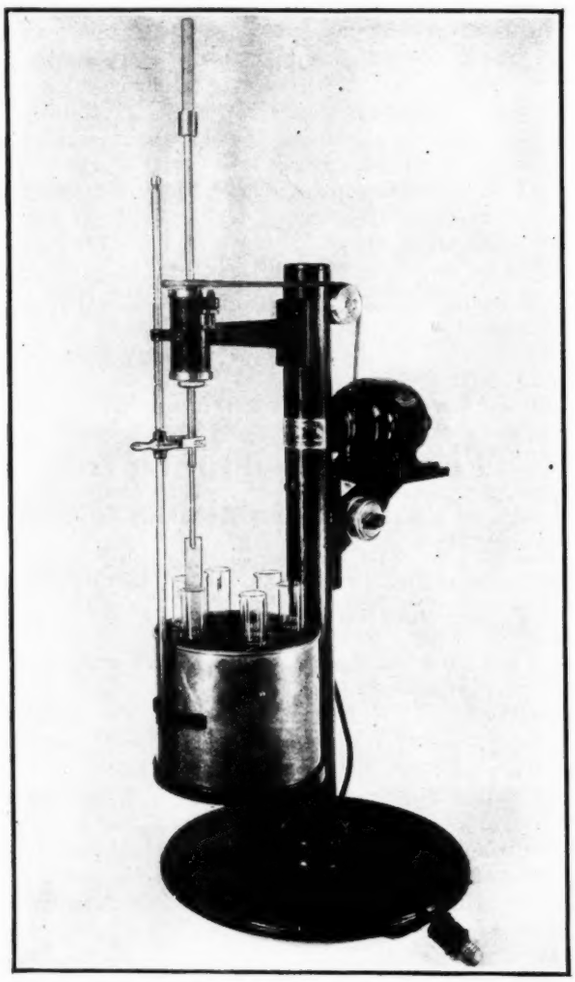
In previous forms of apparatus used in making the emulsion and demulsibility tests (J. R. Battle, "Industrial Oil Engineer," pp. 337 to 339, 1920) the bath was raised and lowered. It is an advantage to have the water bath large enough to hold say half a dozen cylinders, so that no time shall be lost in waiting for the liquids in the cylinders to reach the temperature of the bath. When, however, the bath is made large enough for this purpose, it becomes too heavy to raise and lower conveniently.

The Herschel emulsifier, shown in the figure, is an improvement over previous forms of apparatus used for these tests. The bath is large enough to hold six cylinders and remains fixed in position. Only the paddle shaft is raised and lowered, like the spindle of a drill press. The cylinder being stirred is rigidly and automatically held concentric with the paddle. The liquid tachometer is mounted directly on the paddle shaft so that there is no chance for error in speed due to slip of a tachometer drive.

What is needed is a reproducible method of agitation at a definite and not too high temperature. With this idea Herschel devised the test for "demulsibility," as it is called, which he described in "Proceedings of the American Society for Testing Materials," Vol. 16, Part 2, p. 248, 1916, and in Bureau of Standards Tech-

nologic Paper No. 86, 1917. As slightly modified and adopted by the government committee, now known as the Technical Committee on Lubricants and Liquid Fuels of the Federal Specification Board, the test for demulsibility may be described as follows:

Place 27 cubic centimeters of the oil to be tested and 53 c.c. of distilled water in a 100-c.c. graduated cylinder, with about one inch inside diameter. (As the test is not sensitive to slight changes in diameter of cylinder, an ordinary stock cylinder may be used.) Heat the cylinder and its contents by means of a bath to 130 deg. F. Stir by rotating the paddle for five minutes at a speed



ROTATING PADDLE AT 1,500 R.P.M. PRODUCES EMULSIFICATION WITHOUT UNDUE RISE IN TEMPERATURE

of 1,500 revolutions per minute; stop the paddle, withdraw from the cylinder and wipe clean, returning to the cylinder as much as possible of the emulsion. Keeping the temperature of the cylinder constant at 130 deg. F., take readings every minute (or as often as a change is observed) of the position of the line of demarcation between the topmost layer of oil and the adjoining emulsion. Take the first reading one minute after stopping the paddle. With oils that act normally the rate of settling out of the oil increases up to a maximum and then decreases, and the maximum value, in cubic centimeters per hour, is called the demulsibility and is recorded as the numerical result of the test. Each rate of settling is the average rate calculated from the time of stopping the paddle to the time of reading, and values may be found by a simple slide-rule calculation or may be taken from a table.

The table gives a sample condensed record of observations taken during a test.

RECORD OF AN OIL DEMULSIBILITY TEST

Time	Time Since Stopping Paddle, Minutes	Reading at Interface Between Oil and Emulsion	Oil Settled Out, Cubic Centimeters	Rate of Settling per Hour, Cubic Centimeters
9:50	0	80	0	0
9:55	5	77	3	36
10:02	12	67	13	65
10:05	15	63	17	68
10:10	20	61	19	57

The demulsibility in this case would be 68, the highest value in the last column. When the maximum rate of settling has not been reached at the end of one hour, the test is discontinued and the demulsibility is taken as the number of cubic centimeters that settled out in the hour.

It will be noted that since the readings are not taken of fractions of a cubic centimeter or of a minute, the highest possible demulsibility is obtained when 27 c.c. of oil separate out in one minute, giving a value of 1,620 c.c. per hour. If the oil has a viscosity of over about 350 sec. Saybolt Universal or U. and F. viscosimeter at 100 deg. F. or 50 sec. at 210 deg., the demulsibility test should be carried out at 180 instead of 130 deg., but it is inadvisable to use the higher temperature for the less viscous oils as the test will lack sensitiveness.

Although the test was designed primarily for steam-turbine oils, it has been extensively used for automobile and other classes of lubricants. The government specifications (Technical Paper No. 323, Bureau of Mines, 1923) require a demulsibility of 300 for steam-turbine oils and most other oils to which the test is applied, but it is interesting to note that the test is also used for marine-engine oils, with a required demulsibility of zero, since in this case an emulsifying oil is required.

In another government test, for which this apparatus serves equally well, and which is called the emulsion test, the stirring is accomplished as in the test for demulsibility, but equal parts of emulsifying liquid and of oil are used, the former being distilled water, 1 per cent salt solution or normal caustic-soda solution. The test differs also from the test for demulsibility in the method of taking observations, the cylinder being allowed to stand for the specified time (30 minutes or one hour) after which time there should be no continuous layer of emulsion. This method of making observations is simpler than in testing for demulsibility, but the test does not give a numerical value indicating small graduations in quality of the oil. The question is likely to arise whether there is or is not sufficient emulsion remaining to constitute a "continuous layer."

Obviously, other emulsifying liquids than distilled water can be used as readily with the test for demulsibility as with the emulsion test herein described, and the Prime Movers Committee of the National Electric Light Association (1922 report, page 329) suggests 3 per cent salt and 1 per cent caustic soda solutions. It is especially desirable that an operating engineer, when testing for his own information and not for comparison with other laboratories, should use the water that is available for boiler purposes.

Don't neglect the ammonia condenser. Keep it free of sediment and scale. Don't try to get along with an insufficient charge of ammonia; keep enough in the system so that there is at least 4 to 6 in. in the gage-glass.

Close Regulation

By H. W. PHILLIPS*

THE average engineer is a believer in close regulation, although he may never have given serious consideration to its benefits or attempted to formulate an exact definition of the term. It is generally desirable to maintain a constant steam pressure. The chart from a recording gage that shows a perfectly smooth line is a strong recommendation for the type of regulator used to control the steam pressure. The question is, Would a few pounds variation be of serious consequence? The engine or turbine that shows but 2 per cent speed variation from no load to full load, is also interesting and as a rule would be preferable to one showing 4 or 6 per cent, provided there were no disadvantages which in actual practice would offset the slight superiority of the sensitive governor. The same may be said of the electric motor. The idea of an electric generator that gives exactly the same voltage both at no load and full load without hand regulation or, if the customer prefers, 5 or 10 per cent higher on full load also sounds well, but in nearly all cases, the difference of a few volts would be of but slight importance. In order to meet the real or fancied demand for close regulation, it would appear that the manufacturer sometimes is compelled to sacrifice other features that are more desirable. The purchaser sometimes specifies the regulation, as a rule giving only the no-load and full-load values to be met and so compels a sacrifice in stability. In other cases he may assume that the results shown by tests or guarantee are of sufficient importance to render a close examination of the means by which they are to be obtained unnecessary. This may result in poor economy in operation.

PURCHASERS of power-plant equipment are sometimes inclined to regard close regulation as universally desirable. The speed of a lineshaft drive or the frequency of a distribution system may be closely regulated for good reasons. On the other hand, close regulation may involve mechanical disadvantages in a prime mover, a geared electric motor or a boiler-draft regulating device. Many readers of this article could add interesting points. "Power" would be pleased to have further discussions on the subject, for publication.

There is no great difficulty, theoretically at least, in designing a governor to give very close regulation, or in modifying the design of a given governor so as to make it more or less sensitive. Assuming that the system of flyball weights acted upon by centrifugal force, which is the actuating feature of all governors, remains the same, there are at least three methods by which the sensitiveness may be varied. The system of levers by which motion is transmitted from the weights to the governor valve may be so altered as to produce greater corresponding valve movement. A very small movement of the weights, caused by a small change of speed, may then be sufficient to throw the valve from its wide-open to its closed position. There are obviously bad engineering features in such an arrangement. It may work satisfactorily if the valve is perfectly balanced in all positions and friction practically eliminated in the entire governor mechanism, but any resistance offered by the valve will exert too great a force against the governor movement to allow satisfactory operation under working conditions.

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As a matter of fact this method of obtaining sensitiveness is not more likely to lead to trouble than others, although its weakness is perhaps more obvious. Instead of changing the lever system, we may work on the governing valve itself, increasing its diameter or port openings so that a much smaller motion of the valve is sufficient to allow full steam pressure to act on the engine. The larger valve is more difficult to balance accurately and is likely to show more friction than the smaller one; the probabilities of trouble are therefore much the same as in the previous case. The usual method is to work on the governor itself, changing the springs that oppose the centrifugal force acting on the weights and so determine the position of the governor.

In order to simplify both the illustration and the theory, the force of gravity will be substituted for centrifugal force in the two governors represented in Fig. 1. These are identical in all respects except that the spring *B* is twice as long as that of *A*, although both are wound of the same wire. The lever *D* simply serves to transmit motion from the governor weight to the valve, the weight being supported by the spring only. If the small weight *C*, which will represent the increase in centrifugal force due a definite increase in engine speed is hung to the weights *W*, the governing movement *G* will be twice as great as *F*. It may be assumed that *G* is sufficient to throw the valve from the wide open to the closed position for the change of speed which occurs.

If the mechanism sticks so that a force equal to the weight *C* is required to induce motion, the same change of speed will be necessary to produce this force with either governor. When the valve is freed, governor *B* will close it completely, causing the speed to fall rapidly until the speed change is enough to move it again, when it will probably open to the full extent. With governor *A* the valve will close only halfway for the same change in speed, which will give more nearly the proper flow of steam and less rapid variations in speed. Looking at it from a slightly different angle, we may assume that when friction, an unbalanced valve, or any other force preventing a perfectly free motion of the valve is equal to one-half of the weight *C*, it will cause twice as great a displacement of the valve from its proper position with governor *B* as with governor *A*, and therefore produce undesirable speed variation or perhaps surging to a much greater extent in governor *B*. We are evidently more likely to have a hunting action with *B* than with *A*. Also, it will be noted that between the no-load and full-load speeds governor *A* has twice as much force available for moving the valve as *B*. All of this tends to render *A* more positive in its action and less likely to give trouble from hunting than *B*.

As a rule no question is raised as to the speed varia-

tion between any other points than full load and no load, although in actual practice the intermediate speeds are of as much or greater importance. The speed at half-load is generally nearer the no-load speed than the full-load; consequently, on light loads we may have in effect a governor with an exceedingly long spring and likely to begin hunting on very slight provocation.

Close Regulation of Speed or Frequency Is Desirable, But the Possibility of Hunting Should Be Avoided

In considering the actual application of the steam engine or turbine, close regulation is perhaps most desirable in the case of driving a considerable amount of lineshaft. In this case the engine will seldom run at less than half-load and with a large number of machines taken off the same system of shafting it is desirable to hold a pretty constant speed.

When direct connected to a pump or fan, the load seldom varies between very wide limits, but it is in most cases an advantage to have the engine slow down a small amount on heavy loads and speed up slightly as the load falls off. Great irregularity of speed or hunting is, however, objectionable in nearly all cases and may be aggravated by the inertia of the water in a pipe line of any considerable length. Close regulation is therefore to be preferred. A direct-current generator, direct connected, may run for considerable periods anywhere between no load and full load. Here, however, we are directly concerned only with the maintenance of a constant voltage on the line; if that remains constant, the variation of speed within reasonable limits, is of little moment. The compounding of the generator may be readily adjusted to take care of a considerable amount of variation of speed with load provided variation is a definite quantity, a given speed always for a given load. It is also the duty of the attendant to maintain a constant voltage by use of the field rheostat, which he can do without difficulty so long as the tendency to change is gradual, but which he cannot hope to accomplish with sudden changes.

Any hunting action that may result from too close a

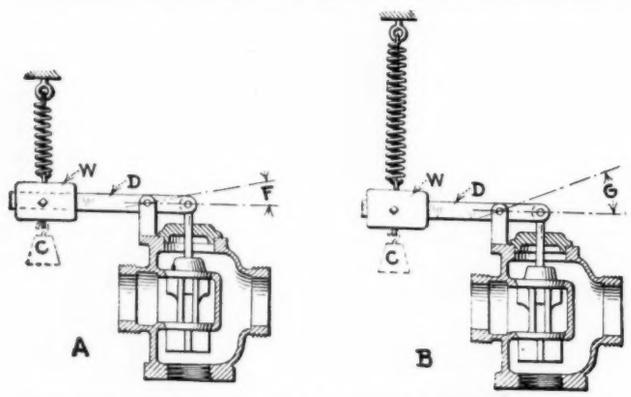


FIG. 1—REGULATION AS AT *A* IS MADE CLOSER AND SURGING MORE IMMINENT, BY INCREASING ACTIVE SPRING LENGTH AS AT *B*

regulation is most objectionable, for even though the speed variation is very small it will be plainly visible on the lights and may have rather an unwholesome effect on motors. With two or more generators running in parallel the difficulty of maintaining an equal distribution of load increases with the closeness of the speed regulation. The generator which slows down as the load strikes it, will not receive its share of overload when another in parallel tends to speed up at that instant.

In some cases, such as a small generator carrying an elevator as a considerable portion of its load, close regulation is essential to avoid the flicker of the lights. In the majority of instances, however, where the sudden changes are not a very considerable part of the capacity of the machine, the freedom from any tendency

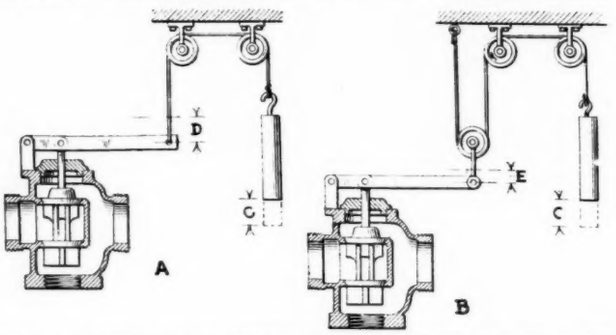


FIG. 2—BOTH REGULATION AND STABILITY AS AT *A* ARE INCREASED BY SUPPLYING GREATER LEVERAGE BETWEEN GOVERNOR AND VALVE AT *B*

to hunt and the proper distribution of loads between machines running in parallel is of far more importance. This often may be best obtained by the sacrifice of close regulation. It has been found that alternating-current generators will not run well in parallel when prime-mover governors are set to give close speed regulation. In order to maintain constant frequency and facilitate bringing two machines into synchronism, the governor is generally so arranged that the speed adjustment may be varied by the operator while machines are running.

The voltage regulation of the compound-wound direct-current generator is taken as the variation between full load and no load. It is sometimes specified as "flat" compound, the same at both loads, and sometimes over-compounded so that the voltage rises 5 or 10 per cent from no load to full load. To adjust the generator to do either is a simple matter which is generally attended to with care by the manufacturer. This is really of comparatively little importance. If a flat-compounded generator would really give the same voltage at all loads, irrespective of whether load is increasing or decreasing, it would be highly desirable, but this is never the case. The point of real importance is the momentary jump in voltage produced by sudden load variations such as will be frequently experienced in actual operation. These as a rule, are not very large and are cared for quite successfully by the ordinary generator. There is no harm in close regulation of the generator, in fact, the closer the better, but when measured in the ordinary manner, between no load and full load, there is very little significance in such specifications.

Close Speed Regulation of a D.-C. Motor Often Defeated by Other Conditions

With the direct-current motor there is less demand for close regulation at the present time than there was in the past. The manufacturer will generally guarantee that the speed will not vary more than a small percentage between full load and no load. Sometimes the customer will insist on having a still smaller variation. As a rule it will not trouble the manufacturer to meet such requirements; it would be better policy on the part of the customer to specify that the variation

should not be less than a certain amount, say 4 per cent, rather than not to exceed a given value. Some motors have practically the same speed at full load and no load, with a half-load speed lower than either; others show a tendency to increase their speed on overload. Such a condition is hard on both the motor and the machine which it drives.

Nearly all motors have some inequalities in the power required to drive them, which may be produced by a reciprocating part or a slight defect in gears or shafting, and it is better to slow up imperceptibly for the fraction of a second and allow the inertia of the moving parts to take care of this than to hammer through at an absolutely uniform motor speed. If the speed increases with the load at certain points of the load curve, there is a tendency toward an unstable condition; an increase in load gives an increase of speed, which still further increases the load, etc., representing a vicious circle. For a machine provided with a flywheel, such as a press or shear, a compound motor is generally specified, which means a variation of between 10 and 25 per cent. Here again it might be well for the customer to specify a minimum and perhaps a maximum allowable variation. There are some few instances where it is essential that the speed should be as nearly constant as possible under varying loads. If this is the case, it is necessary to have unusually close regulation of voltage at the motor terminals and to provide a field rheostat to control the increase of speed that a direct-current constant-speed motor always experiences as it warms up. Unless these refinements are provided there is little use in calling for unusually close regulation. Even in such cases there is seldom a possibility of the motor running on no load in service; special speed regulation should therefore be called for only on range of loads under which it will operate in service.

SOME APPLICATIONS OF CLOSE REGULATION CLASSIFIED WITH REGARD TO DESIRABILITY IN ORDINARY CASES

Desirable	Merit Open to Discussion	Undesirable
(a) Lineshaft speed	(a) Flat compounding of a d.c. generator is less significant than voltage variation at points between no load and overload.	(a) Speed adjustment of prime-mover governors, in relation to parallel operation.
(b) Pump or fan speed	(b) Speed adjustment of prime-mover governor in relation to voltage compound of a d.c. generator.	(b) Motors, connected to gearing or loads subject to mechanical shock.
(c) Voltage at motors	(c) Speed of d.c. motor where required very nearly constant, but where no field rheostat is provided to take care of temperature changes in field resistance.	(c) Pressure held by a reducing valve.
(d) Speed adjustment of prime-mover governors in relation to sudden load surges		(d) Hydraulic regulator for damper or draft fan.

The reducing valve adjusted for close regulation frequently develops a pumping action that necessarily shortens the life of the valve and frequently defeats its own purpose of holding a constant pressure. A slight change in pressure produces too great a movement of the valve, with the result that it overshoots the mark. The trouble may be accentuated by the inertia of the steam moving at high velocity through a long line of pipe. When the valve is closing the effect is not felt immediately at the far end of the pipe, but near the valve there is an exaggerated effect due to the checking of the rapid flow. This tends immediately to throw the valve wide open, only to close again a few moments later. Of course it is advantageous to hold the reduced pressure as nearly constant as possible, and so long as there is no pumping all is well. It is usually impracticable to design a valve for the exact conditions that it will encounter in the particular location where it is installed, but it may be that the average performance would be more satisfactory if a greater change were allowed between the maximum and minimum steam flow. Incidentally, it may be said that in a great many cases the valve installed may be too large to give the best results, a reducing valve is seldom found to be working up to its full capacity, and of course a large valve is more likely to start pumping than a small one.

Broad Regulation Suits Hydraulic Draft Control

The hydraulic regulator attached to a boiler damper or forced-draft engine for the purpose of maintaining constant steam pressure is another case where a too sensitive condition often exists. Although the load on the boiler may be practically constant, it is seldom that the damper maintains a fixed position or the fan a constant speed. The usual condition is to find the fan running at maximum speed for a few minutes, followed by a period of minimum speed or even absolute shutdown. The variations of the damper are usually less marked, but that also will be found to be shifting through rather wide limits. Such conditions are hard on the regulating apparatus, the fan engine and the boiler settings and have a tendency to lower the fuel economy. While all this is going on, the recording pressure gage will show very little variation in pressure; the apparatus is, in fact, too sensitive.

Although the perfect circle on the chart may be a thing of beauty, is a variation of a few pounds between the maximum capacity and the time when it is delivering very little steam, a matter of serious consequence? If it is, then there are but few cases where this change in load occurs outside of well-known intervals of time, and it is a simple matter for the engineer to give the regulator a slight adjustment by hand, when they are to be met. In the case of the fan engine the extreme variations in speed may not be entirely the fault of the regulator itself.

Where the regulator controls through an ordinary balanced valve, as is frequently the case, it is generally connected as at *A* in Fig. 2, a slight movement *C* of the regulator, perhaps a quarter of its maximum stroke, transmits enough motion *D* to the valve to bring the engine from minimum to maximum speed. The operation will be improved if the connection is made as at *B*, where an equal movement of the regulator produces a smaller movement *E* of the valve. Here *E* equals one-half of *D*. More pulleys may in some cases be added to advantage, causing the regulator to operate through three or even four parts of chain. Special valves and special regulators are obtainable which are fairly successful in overcoming the conditions described. As they are considerably more expensive than the ordinary types and have not been on the market for a very great length of time, they are not as yet in general use.

Simple Principles Controlling Choice of Regulation Deserve Study

The table gives a summation of results, classified as to the desirability of the cases discussed. This represents general conditions only. Special applications must be decided on their own merits, where the controlling factors can be reviewed and weighed to better advantage than in an article of this kind.

Needless to say, the subject of the most desirable regulation of speed, voltage pressure or any other variable, as expressed in percentage, includes a countless number of applications. Discussion of these reveals that a comparatively few simple basic principles govern the choice of proper regulation.

As regulation is shortened, the point is approached where occasional or permanent hunting or surging takes place in a governing device. The motor, prime mover or generator subject to this regulating action is also subjected to increasing mechanical shocks. On the other hand, close regulation is commercially desirable in order to produce the necessary degree of uniformity of speed, light, pressure, etc., as related to production, efficiency, human comfort or other requirements. Further principles may be gathered from practical experience and analysis. The subject is far from a state of general knowledge, especially in regard to the actual solving of such problems, from an engineering point of view.

The Brock Improved Type of Feed-Water Purifier

A number of important changes have been made in the construction of the water purifier manufactured by the Brock Engineering Co., St. Louis, Mo., the original illustrations and design of which were given in the March 21, 1922, issue of *Power*.

Before these changes are enumerated it might be well to review the principle on which the purifier operates. This will be readily understood by referring to the illustration.

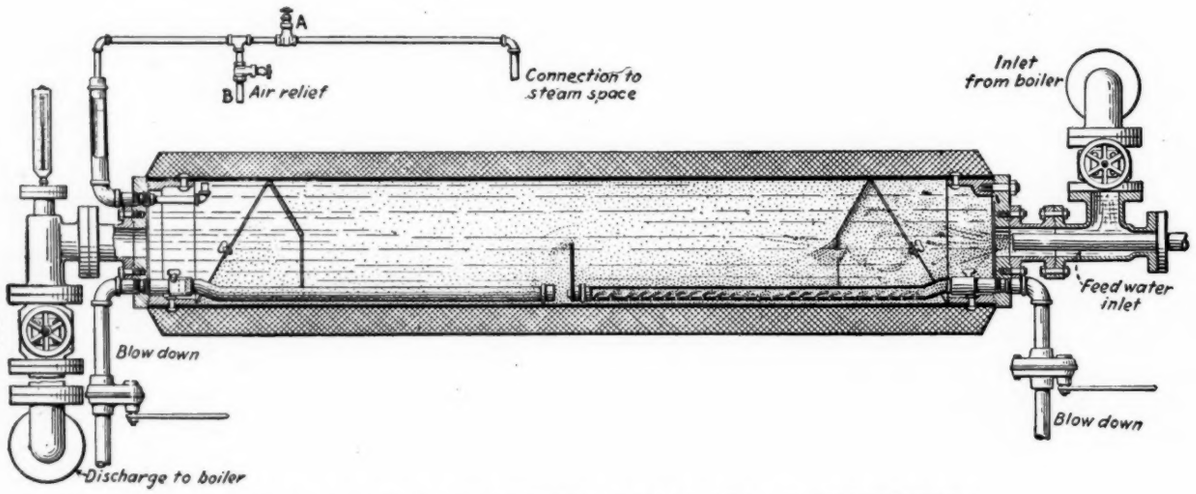
The purifier is placed close to the boiler in a suitable location and connected to the water and steam space of the boiler as indicated. The feed water, presumably heated in a standard feed-water heater to about 170 deg. F., enters through the straight pipe inside the tee at the right. The upper opening, 4 in. in diameter, carries the water from the boiler into the purifier, where it is mixed with the feed water. These two streams are combined and the velocity is retarded considerably by striking the baffles, which also deflects the current toward the bottom of the purifier.

There is now a considerable basin through which this warm water must pass, and as the purifier carries the same pressure as the boiler and the bulk of the water contained in it has been heated in the boiler, the temperature is about 300 to 350 deg. F. Owing to the high temperatures of the water and the comparatively slow movement through the purifier, all the carbonates and, it is claimed by the manufacturer, about 95 per cent of the sulphates are precipitated and settle in the bottom of the shell, whence they are removed by blowing down. The water returns to the boiler through the 4-in. connection at the discharge end of the purifier, at the left.

Probably one of the most important improvements made in the purifier is the construction of the drum, which is now made of a seamless steel shell having annealed steel flanges riveted to the ends, all the seams being calked and a cast-steel head bolted to the ends.

The heads may be removed and the baffles loosened from their position by unscrewing one bolt. This may be done without disturbing any other part of the purifier. The blowoff pipes are also put in with a bayonet lock; this allows the heads of the shell to be removed without disturbing the blowoff pipes. Also, by removing one head it is possible to remove the entire inside mechanism.

Considerable change has also been made in the design and location of the baffles and a center baffle has been added. Two independent blowoff pipes are now used.



SECTION SHOWING ARRANGEMENT OF BAFFLES AND CONNECTIONS

Another feature is the provision made for removing the air that may be entrapped in the purifier. This effect is obtained by using the small vent pipe turned upward within the purifier and reaching close to the shell. This vent is connected to a standpipe on the outside, which contains water at the same level as that in the boiler. The top of the standpipe is connected to the steam space of the boiler by a ½-in. line fitted with a stop valve *A* and a drip or vent connection *B*. Closing valve *A* and opening valve *B* allows all the air to discharge until the water is carried through, then the valves are reversed. Such air as may be carried into the purifier with the feed water will seek the water level of the boiler and pass into the boiler and hence through the steam line.

As the purifier is subjected to boiler pressure, its construction is based upon the figures and formulas for marine service and also conforms with the A. S. M. E. Boiler Code.

The Weekly Boiler Trial Sheet

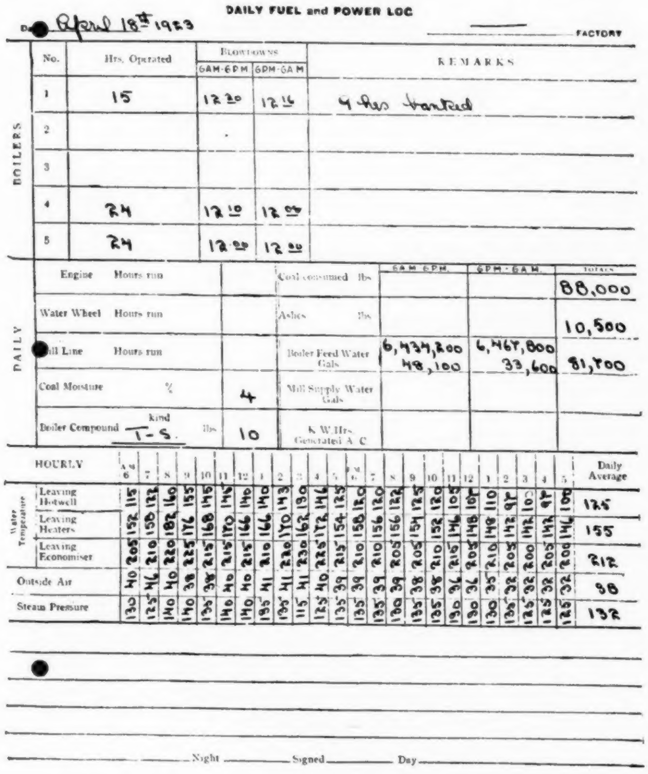
By DONALD ROSS-ROSS

THE present-day power-plant engineer has more and more the desire to keep himself informed as to the general performance of his boiler plant, with special reference to the rating he is operating under, the efficiency he is obtaining and the evaporation per pound of coal. It is quite desirable that he should know these things, for they aid him to see the conditions that will bring about the highest efficiency in his plant. Having once found such conditions, he will be quick to see when the efficiency falls off and to investigate the reason thereof.

To the average engineer the simpler this information can be obtained the better. It is, therefore, the intention in this article to elaborate on the simple method employed in a large Canadian manufacturing plant in collecting, compiling and recording the necessary data from the boiler plant.

The first step was the beginning of a daily log sheet, Fig. 1, the installation of a feed-water meter, recording thermometers to the hotwell, feed-water heater and economizers, and a thermometer to take the temperature of the outside air.

To keep all the records neat and clean, the stationary engineer sends in to the office each morning the daily,


DAILY FUEL and POWER LOG

Date April 18th 1923 ______ FACTORY

	No.	Hrs. Operated	Blowdowns 6AM-6PM	Blowdowns 6PM-6AM	Remarks
BOILERS	1	15	12.20	12.16	9 hrs. banked
	2				
	3				
	4	24	12.10	12.05	
	5	24	12.20	12.00	

DAILY				6AM-6PM	6PM-6AM	Totals
Engine Hours run			Coal consumed lbs.			88,000
Water Wheel Hours run			Ashes lbs.			10,500
Mill Line Hours run			Boiler Feed Water Gals.	6,434,200 48,100	6,467,800 33,600	81,700
Coal Moisture %		4	Mill Supply Water Gals.			
Boiler Compound kind T-S. lbs.		10	K.W.Hrs. Generated A.C.			

HOURLY	AM 6	7	8	9	10	11	12	1	2	3	4	5	PM 6	7	8	9	10	11	12	1	2	3	4	5	Daily Average
Water Temperature Leaving Hotwell	115	122	160	155	145	145	140	140	143	130	146	125	120	120	122	125	120	105	107	110	98	102	98	100	125
Leaving Heaters	152	158	182	176	168	170	166	166	170	162	172	154	158	156	156	154	152	146	148	148	142	142	142	146	155
Leaving Economiser	205	210	220	225	215	215	215	210	220	230	225	215	210	210	205	205	210	215	205	210	205	200	205	200	212
Outside Air	40	46	40	38	38	40	40	41	41	41	40	39	39	39	39	38	38	36	36	35	32	32	32	32	38
Steam Pressure	130	125	140	140	135	140	140	135	135	115	125	135	135	135	130	135	135	130	130	130	135	125	125	125	132

Night ______ Signed ______ Day ______

FIG. 1—DAILY FUEL AND POWER LOG SHEET

half-daily and hourly readings on the multigraphed forms supplied to him, together with the charts of the recording thermometers and steam-pressure gage. These are then entered up on the "Daily Fuel and Power Log" (Fig. 1), which is afterward put in a binder kept for the purpose.

On Monday morning of each week the results for the seven preceding days are totaled or averaged, as the case may be, and the figures so obtained are entered on the "Weekly Boiler Trial Sheet," (Fig. 2). This trial sheet is a much abbreviated and simplified form of the boiler trial sheet specified by the American Society of Mechanical Engineers Power Test Code.

First of all the date is filled in under item 1. To obtain the boiler hours for item 2, the number of hours

WEEKLY BOILER TRIAL SHEETS

1. Date at completion of test .... April 16, 1923
2. Boilers operated, hours 412.5
3. Weight of coal used, lb. 526,000
4. Moisture in coal, per cent 3.21
5. Ash in coal, per cent 11.35
6. Evaporation, total, lb. 5,274,000
7. Average steam pressure, lb. gage 128.5
8. Average temperature leaving hotwell, deg. F. 128.5
9. Average temperature leaving heater, deg. F. 167.3
10. Average temperature leaving economizers, deg. F. 214.5
11. Average temperature outside air, deg. F. 33.6
12. Factor of evaporation 1.0899
13. Equivalent evaporation from and at 212 deg. F., lb. .. 5,748,130
14. Equivalent evaporation, per hour, per boiler, lb. 13,934.8
15. Number of boilers in operation 3
16. Equivalent evaporation, per hour, per boiler at rating lb. 12,075
17. Percentage of rating developed 115.5
18. Actual evaporation per pound of coal, lb. 10.0
19. Equivalent evaporation from and at 212 deg. F. per pound of coal as fired, lb. 10.92
20. Efficiency of boiler and furnace, per cent 75.4
21. Cost of coal per ton, dollars 9.12½
22. Cost of coal to evaporate 1,000 lb. water from and at 212 deg. F., cents 41.8

FIG. 2—WEEKLY RESULTS OF BOILER PLANT

the boiler is operated, whether under load or banked, is added up and the total for all boilers entered. For item 3 the coal consumption for the seven days is added together and written in this space. To obtain the percentage of moisture in the coal, the plant engineer is supplied with a method of drying a quantity of coal, and hence the loss in weight in the drying process divided by the original weight of the coal gives the percentage of moisture. The average for the seven days is filled in item 4. From the "Daily Fuel and Power Log" the total quantity of ash for the week is found, and when divided by the quantity of coal for the same period, we find the percentage of ash for item 5. Item 6 is readily obtained by the difference of the readings of the water meter at the beginning and the end of the week. Items 7, 8, 9, 10 and 11 are simply the averages for the week.

The simplest method of obtaining the factor of evaporation (item 12) is to draw up a chart, as shown in Fig. 3, having the curve *A* for the factor of evaporation when the feed water is at 32 deg. F. and the correction curve *B* for the feed waters above this temperature. The actual factor will be the difference between these two.

To draw up such a chart, the reader has only to lay out a sheet of cross-section paper as in Fig. 3. Then to obtain the points on the curve *A*, take each steam pressure as given by the gage; add 15 lb. to bring it to absolute pressure; from the steam tables find the total heat *H* corresponding to each pressure so obtained; and then divide these figures by 970.4 (the latent heat of steam at 0 lb. gage). The answers thus derived, when plotted, will give the curve *A*. For example, if we want to find the point on curve *A* for 110 lb. gage, we find in the steam tables, opposite 125 lb., that the total heat, *H* is 1,190.3 B.t.u., and when this is divided by 970.4, the factor is 1.2266. The curve *A* is based on the assumption that the feed water is at a temperature

of 32 deg. F., which is not the case in practice. To correct for the higher feed-water temperature, curve *B* is plotted. It is a straight line, and therefore it is necessary only to get the two end points and join these with a straight line. To do so, take the heat of the liquid *h* corresponding to the feed-water temperatures at each end of the chart, and divide by 970.4. Thus, for 50 deg. F. the heat of the liquid is 18.08 B.t.u., the corrective figure is 0.0186, and so on.

As the economizers form an integral part of the boiler, it must be considered as adding to the boiler and furnace efficiency. Therefore, the temperature of the water leaving the hotwell is taken as the feed-water temperature. Thus, for example, take the boiler pressure as 128.5 lb. gage, then from the chart the factor *A* is

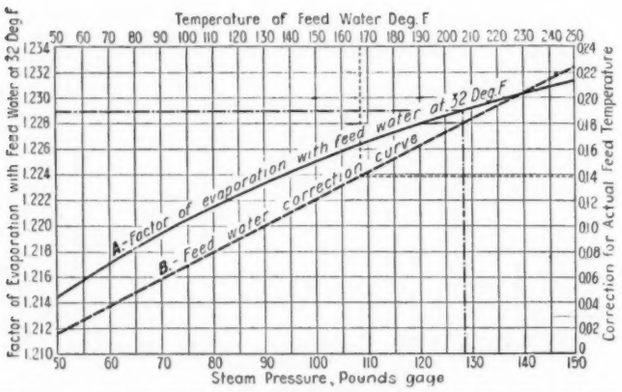

Temperature of Feed Water Deg. F
Factor of Evaporation with Feed Water at 32 Deg. F
Correction for Actual Feed Temperature
A-Factor of evaporation with feed water at 32 Deg. F
B-Feed water correction curve
Steam Pressure, Pounds gage

FIG. 3—CHART FOR DETERMINING FACTOR OF EVAPORATION AT DIFFERENT FEED TEMPERATURES

1.2285, as shown by the dot-and-dash line on the chart, Fig. 3. Assume the feed-water temperature to be 167.3 deg. F., and this gives *B* as 0.139, as indicated by the dotted line. The difference between these two is 1.0899.

Having found the method for obtaining the factor of evaporation, some readers will ask what its specific object is. The answer to this is best shown when we come to look back over the various boiler plants in which we have worked. In every case the operating conditions vary as to working pressures, feed temperatures, etc. It is easy to see that the higher the pressure and the lower the feed temperature, the less water will be evaporated per pound of coal. To make comparisons possible between the performance of one boiler plant and another, it has been decided to take a standard condition, and that standard is the amount of water evaporated with feed water at 212 deg. F. into steam at 212 deg. F. or 0 lb. gage, hence, the expression "Equivalent evaporation from and at 212 deg. F." Thus, by multiplying the pounds of water fed (item 6) by the factor of evaporation (item 12), we obtain the equivalent evaporation (item 13).

The normal rating of a boiler is given as 3.45 lb. of water per square foot of heating surface per hour from and at 212 deg. F., therefore the boiler rating developed, per cent, equals equivalent evaporation per square foot divided by 3.45 and multiplied by 100.

Item 15 can readily be filled in. Item 16 is found by multiplying the square feet of heating surface in one boiler by 3.45. The rating (item 17) is obtained by dividing item 14 by item 16; item 18 is obtained by dividing item 6 by item 3; and item 19 by dividing item 13 by item 3.

In order to obtain the efficiency of boiler and furnace,

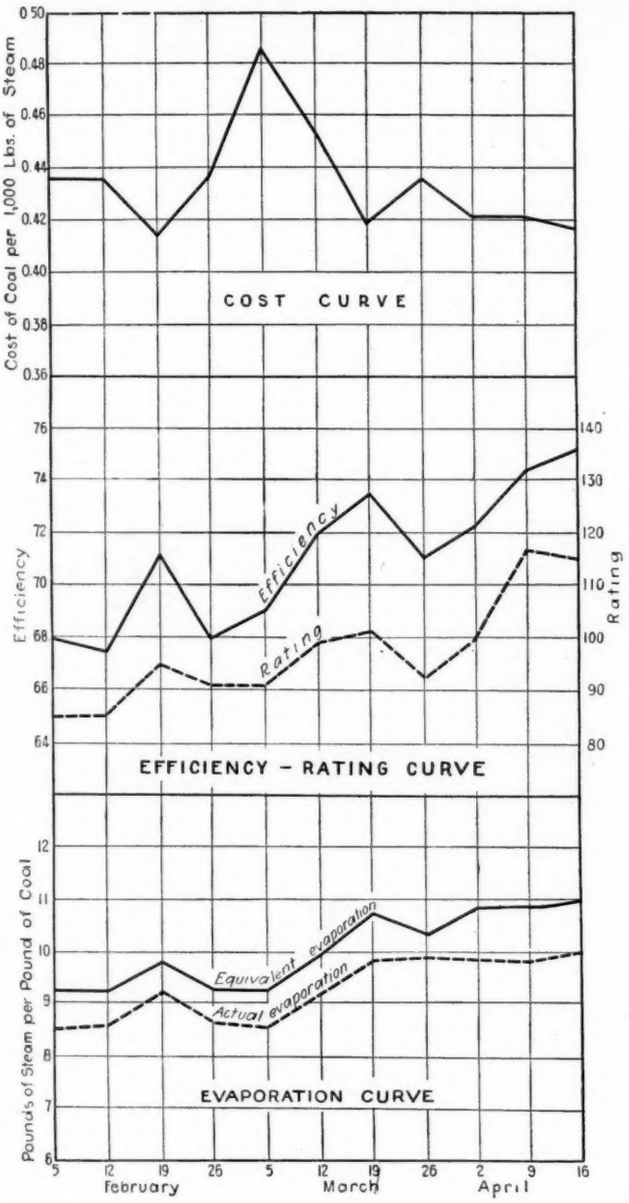


FIG. 4—CURVES SHOWING RESULTS OVER A PERIOD OF TEN WEEKS

With these curves before him, the plant engineer can see what weeks he got the best performance out of his boilers and to some extent why this occurred.

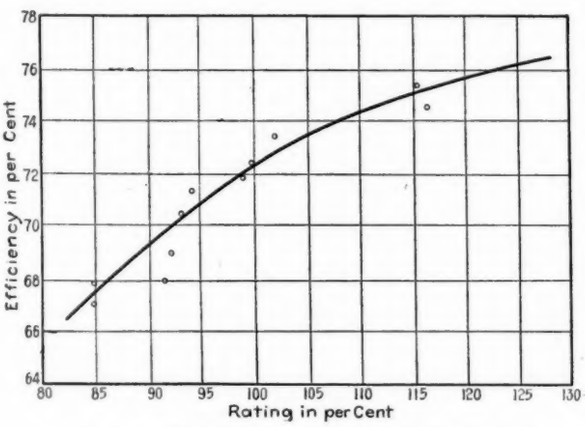


FIG. 5—RATING AND EFFICIENCY CURVE

it is necessary to know the calorific value of the coal per pound. If it is impossible to have this found at the plant, a sample of coal can always be sent out for test. Failing this, the heat value can be got approximately by looking up the analysis of coal for the mines from which it comes in some government bulletin. The actual efficiency in per cent is derived by multiplying the equivalent evaporation per pound of coal (item 19) by 970.4, the latent heat of evaporation at 212 deg. F., and by 100 and then dividing the product by the calorific value of 1 lb. of coal.

$$\textit{Efficiency, per cent} = \frac{\textit{Item } 19 \times 970.4 \times 100}{\textit{Calorific value } 1 \textit{ lb. of coal}}$$

or in other words the heat given to the water divided by the heat contained in the fuel.

For item 21 the cost of coal per ton including coal and ash cartage is filled in.

To calculate the cost of 1,000 lb. of steam (item 22), it is necessary to find the cost of 1 lb. of coal; then divide item 19 into 1,000, and multiply the cost of 1 lb. of coal by the answer so found. This completes our "Weekly Boiler Trial Sheet."

There are a few good lessons to be learned from the results obtained, and these are best seen by plotting each week charts, Fig. 4. With these before him, the plant engineer can see what weeks he got the best performance out of his boilers and to some extent why this occurred.

For example, it was noticed that each week when the rating was high so also was the efficiency high, as shown by the curve, Fig. 5. It is true that the points plotted do not all fall on the curve. This is due to a number of conditions, among which are variations in the quality of firing, variations in the temperature of the outside air as used for the forced draft, etc.

There are many interesting factors entering into the operation of a boiler plant, and the more these can be visualized the easier is it to separate out each phase and to study it with the idea of getting, ultimately, the best out of the whole plant.

Strength Test of Water Turbine Runner

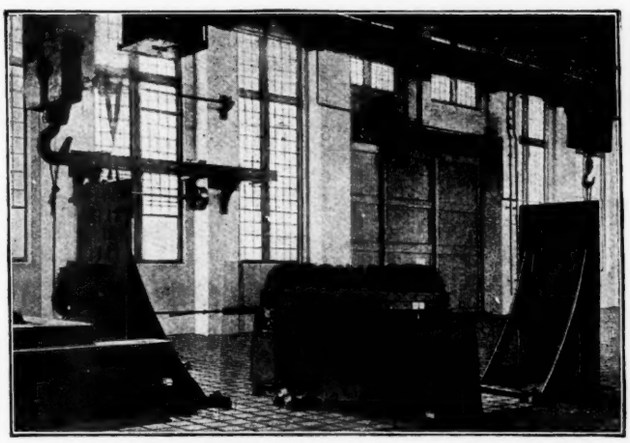
By John S. Carpenter*

The composite steel-plate and cast-iron runner for water turbines has been in use for a great many years and possesses certain well-defined advantages over the solid cast runner.

In the specifications of a well-known consulting engineer a runner strength test was included. This is not a usual requirement by any means, and under the conditions of the test prescribed it is quite safe to believe that runners made by the common method would have suffered severely. Referring to the cut, we see that a steel ring was clamped to the runner band and provided with cables to pass over pulleys and thence to the hooks of the crane scales, the scales being held by the 60-ton shop cranes. The hub of the runner having been bolted fast to the cast-iron floor plates, two pointed indicators were bolted to a stand and marks made at diametrically opposite points on the runner band. Thus a zero mark was established to show the extent of angular deflection or deformation.

The pull on the ring was then built up in steps and the amounts noted on the crane scales. The corresponding angular deflection was also measured and plotted against pull. This process was continued until the pull was four times the normal runner torque created when producing full power at full head of water. The deflection as measured proved to be in direct proportion to the pull in each case, showing that the runner had not been stressed beyond the elastic limit. This condition of stress was held for about an hour, after which the consulting engineer took a heavy sledge and hammered the rim to see if additional deformation would be caused thereby, but the indicator did not show further deflection.

After the pull was removed, the runner band returned to within $\frac{1}{64}$ in. of the original zero mark. This procedure constitutes a very severe test, the hammering on the band being enough, usually, to destroy the union between the steel-plate vane and the cast-iron band. A similar test was carried out on another runner for an important hydro plant, but the hammer test was omitted.



METHOD OF PUTTING TEST ON TURBINE RUNNER

*Hydraulic Engineer, S. Morgan Smith Co., York, Pa.

Discharge Temperatures of Carbon-Dioxide Compressors

By T. M. Gunn

In *Power* Oct. 24, 1922, there appeared an article entitled "Diagnosis in Ammonia-Compressor troubles," accompanying which was a chart giving the discharge temperature for ammonia compressors under ideal conditions. The writer has been asked by several readers to supply a similar chart for carbon-dioxide compression.

It is unfortunate that the properties of carbon dioxide have not been determined with the same accuracy as those of ammonia. Various authorities differ considerably on the values ascribed to both saturated and superheated carbon dioxide. The chart for carbon-dioxide compressor discharge temperatures has been plotted on the basis of the properties shown by the tables and charts of Professor Macintire, and can be assumed to be near enough for practical purposes.

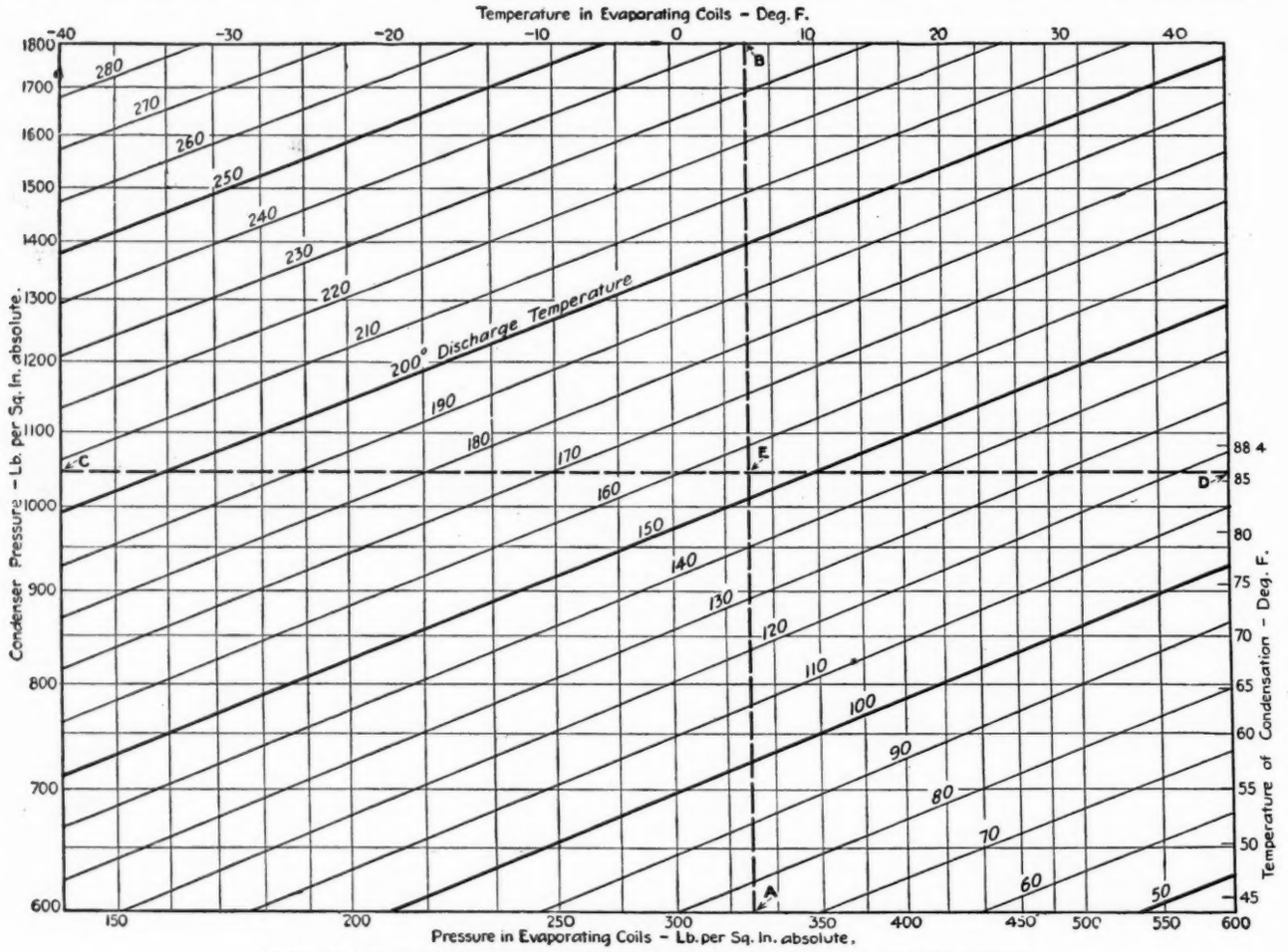
A brief explanation will be given as to the meaning of this chart and its use in connection with the carbon-dioxide refrigerating plant.

Across the bottom of this chart is a scale showing the pressure in evaporating coils, in pounds per square inch absolute (gage pressure plus 15 lb.). For any given

pressure in the evaporating coils the corresponding temperature may be found by running a vertical line to the top scale.

The scale at the left side of the chart is for condenser pressure. Within the range up to the critical temperature (88.4 deg. F.) the temperature corresponding to the pressure may be read at the right-hand side of the chart, opposite the pressure.

An example is shown by dotted lines on the chart. At the point *A* is indicated an evaporating coil pressure of 330 lb. The vertical line extends to the point *B* at the top of the chart, where the coil temperature is found to be 5 deg. F. A condenser pressure of 1,025 lb. is indicated at the point *C* on the left-hand scale. The horizontal dotted line extends across to the point *D*, where the temperature of 86 deg. is indicated on the right-hand scale.



TEMPERATURE-PRESSURE CHART FOR CARBON DIOXIDE COMPRESSORS

At the intersection of the horizontal and vertical lines just described is the point *E*. Note that this point lies between the lines marked 150 and 160 and should be read about 155 deg. F. This latter figure is the calculated temperature of carbon-dioxide gas leaving a compressor operating with 330 lb. suction pressure and 1,025 lb. discharge pressure, assuming that the suction gas is dry but not superheated and that compression is adiabatic.

In comparison to the corresponding ammonia chart, previously mentioned, it is noteworthy that the same condition would produce an ammonia discharge temperature of about 210 deg. This difference of about 55 deg. is due, of course, to the variations in the properties of these two substances, especially in regard to the smaller ratio of compression that is possible with carbon dioxide.

As to the purpose that this chart can serve in a carbon-dioxide refrigerating plant, let us enumerate briefly the conditions that might tend to cause the actual discharge temperature to be greater or less than the theoretical figures.

The causes of higher temperatures than shown by the chart are superheated gas entering the suction of the compressor, leaking valves or piston rings or a leaky bypass valve. Causes of lower actual discharge temperatures than the theoretical are liquid in the suction gas and heat interchange with the cylinder walls.

The conditions that tend toward higher temperatures tend to reduce the efficiency of the refrigerating plant. For this reason the use of a thermometer on the discharge pipe of a carbon-dioxide compressor would be a valuable indication to the operator of any of these objectionable conditions of operation, just as it is in the ammonia refrigerating plant. Using such a chart and comparing with it the readings of the thermometer on the compressor discharge pipe, the engineer will soon learn what the temperature difference is when valves and piston rings are in good condition and suction gas saturated. At any time when the thermometer shows a change in this relation, he will know that something is wrong and can take the usual steps to locate the cause and apply the remedy.

EDITORIALS

F. R. LOW, EDITOR

Inspecting Steam Turbines for Evidences of Fatigue

IT IS a quite generally accepted fact among engineers that steam turbines should be thoroughly inspected once each year. The condition of blading, nozzles, packing, lubrication system and bearings, alignment, rotor, coupling, etc., should be determined, recorded and, if necessary, corrected. In relative importance, from the engineer's point of view, these inspections are likely to rank in the order named.

In steam turbines as a whole fatigue plays a minor part in producing deterioration. Frictional wear, dirt, erosion, corrosion, foundation settling or other causes are prominently represented. There is a natural tendency to overlook the former condition for this reason, and also from the fact that a turbo-generator set that has proved itself satisfactory in service, earns a greater reputation for reliability as time goes on.

As a matter of fact, though such troubles are comparatively rare, they may, nevertheless, occur only after a considerable period of satisfactory service. Therefore, cracks or other evidence of fatigue should be more carefully searched for as the unit grows older, instead of being neglected as a result of a feeling of security from such things.

One method of inspection is to look over those surfaces of the rotor most subject to vibration, carefully with a drop-light, so as to detect cracks. Another is to tap with a hammer, so as to produce a dull ring in case of a sufficient crack. A third method is more positive: Coat the surfaces with kerosene and vibrate with a hammer, so as to work the oil into any possible crevices. Clean off the oil and cover with chalk. Again vibrate with a hammer, and oil entrapped in cracks or crevices may then be worked into the chalk, giving an easily detected indication. Factory inspection may be, of course, more thorough, involving mechanical vibration, X-ray or magnetic exploration of the metal. In any case considerable work is required. Continuity of operation and safety, however, justify much expense and delay.

It is perhaps a cause for gratification that in one recent instance the regular rotor inspection revealed cracks that would undoubtedly have caused serious trouble if not discovered. In this case a thorough and painstaking factory investigation of a year before revealed no untoward conditions. Defects, however, in the well-tried machine had developed quite unexpectedly. Further trouble was prevented without appreciable inconvenience to operation.

Thorough inspection at reasonable intervals is a principle that should well apply to all types of steam turbines and other prime movers. Although the length of time in satisfactory service is in many ways a measure of dependability, it does not follow that the effects of fatigue become less and less important. On the contrary they should be considered increasingly important subjects for investigation as time goes on.

Greater Use of Power and Less Immigration

DURING the recent labor shortage there was considerable discussion with regard to alleviating the deficiency by removing the restrictions on immigration. In these columns, in the issue of May 8, it was pointed out that the solution of this problem was not in unrestricted immigration, but in a more efficient use of the labor that this country has available. According to figures recently issued by the United States Bureau of Immigration, less stringent immigration laws will not solve our labor problems. During the year ended June 30 last, immigrant aliens to the number of over one-half million entered this country. These statistics show that only about eighty thousand of these were laborers as against over one hundred thousand skilled workmen and nearly two hundred thousand women and children without any occupation.

This ratio of one in six immigrants entering the country as common laborers is not unusually low, but about the average. As long as this condition exists, anything that may be done to remedy a shortage in common labor by releasing the restriction against aliens entering this country will aggravate the situation rather than help to solve the problem, on account of the large number of unsought-for persons entering at the same time.

A solution of the future labor problems is not to be found in more labor, but in less labor and a greater use of mechanical power. Great advancements have already been made in this direction, but a great deal more has to be done. Where all excavating work used to be done by picks and shovels in the hands of common laborers, it is now done in large part by steam and electric shovels, power operated ditching machines and similar equipment. Where building materials used to be carried up ladders on the backs of human beings, they are now handled by power-driven hoisting machinery. The electric magnet handled by a power-operated crane has replaced thousands of common laborers around steel mills for handling scrap and manufactured products, and power-operated hoists and cranes have become parts of all industries where heavy materials are to be handled. The storage-battery operated truck is replacing the hand-propelled type. In the power plant mechanical coal hoists, conveyors and stokers have replaced the coal passer and fireman. In this country higher wages are paid than in any other country of the world —in some cases this amounts to two or three times that paid in foreign countries—yet American industry can compete in the markets of the world. This has resulted from the use of power, making it possible for one worker to produce with a machine what required several to do by hand. In 1869 an average of six-tenths horsepower was used in this country per wage earner; by 1919 this figure had increased to over three and one-quarter horsepower, which follows along a similar line as the average increase in wages during this period.

Although the use of more efficient methods in industry are primarily in the hands of the management, nevertheless labor has its responsibility. If labor is going to continue to demand a higher wage for its services, it must expect to co-operate to make its efforts more productive. Estimates show that there are over two hundred thousand more miners in the coal industry than required to produce the country's coal. This is with present methods; if modern methods were generally introduced in the coal-mining industry, this figure would be greatly increased. The coal industry is one of the worst offenders, but it is by no means the only one responsible for labor wastes in industry. Until such wastes are eliminated, it will be difficult to see where more labor is required. What is needed, is a checking up on those who are responsible for the lax methods, and if they cannot remedy the conditions other agencies should act to find a solution.

Help the Neighbor Keep Warm!

AS WINTER approaches, the average householder begins to think about keeping warm. If he lives in the northeastern part of the United States, he may be sorrowfully meditating on the price of anthracite in stove or furnace sizes. Perhaps he is considering the possibility of firing the lower-priced "steam" sizes, or coke, or bituminous coal, or some mixture of these fuels. It may be that fuel oil, with its greater convenience and its freedom from worries over strikes, is attracting his earnest attention. Again, he may be giving serious attention to the warming of certain rooms entirely or in part by individual heaters using oil, natural gas, city gas or even electricity.

To make an intelligent comparison of all these methods of heating requires a certain amount of technical knowledge. The all-important question, "What will it cost?" can easily be answered with reasonable accuracy by an engineer furnished with information as to the coal requirements of the house during previous winters and the heating values and unit costs of the various fuels considered. But the average householder, not possessing the technical knowledge for such a scientific comparison, has little to guide him except the reports of neighbors and the claims of enthusiastic salesmen. As a result he may commit himself to unwise expenditures.

It is right here that the engineer can use his knowledge of fuels and heat computations and help his neighbor solve a vital problem. It will only take half an hour to explain the meaning of the heat unit and show how all fuels may be compared on the basis of cost per million B.t.u. or the number of heat units obtainable for one cent. So that he won't forget them, write down the heat value of the various fuels, using (if more precise figures are lacking) 12,500 B.t.u. per pound for anthracite, 14,500 for bituminous, 20,000 for oil, 550 per cubic foot for city gas, 1,000 per cubic foot for natural gas and 3,400 per kilowatt-hour for electricity. With these the local retail prices of the various fuels as a basis, figure out the cost per million B.t.u. of each fuel or the cost of the amount equivalent to a winter's supply of the coal formerly used. This needs only to be corrected for the estimated relative efficiencies with which the various fuels can be applied to give the actual fuel cost of heating in each case.

With these data down in black and white the engineer can show his neighbor how to allow for the practical operating advantages and disadvantages of each fuel and help him to make the final choice best suited to his particular circumstances.

Such a service will be greatly appreciated and give the engineer valuable practice in applying the principles he has worked so hard to learn. But in addition to the personal satisfaction there will be a real gain to the engineering profession at large as the layman comes to a better appreciation of the fact that the engineer has the key to the practical solution of many homely problems.

The Anthracite Agreement

OUTSTANDING results of the Pinchot settlement of the anthracite strike are:

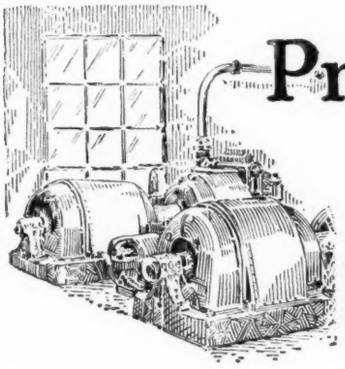
1. Consumers will be assured of full coal bins for the next two winters.
2. The labor leaders probably secured all that they seriously went after, even though the agreement did not meet their full demands.
3. The price of anthracite will not come down, and the public will indeed be fortunate if it does not go up.

During the last five years the steady increase in anthracite prices has been out of all proportion to that of any other commodity, and in response to public opinion the Federal Coal Commission was appointed to ascertain the facts. That body has now completed its work, and the several reports issued have laid bare the factors and practices responsible for the pyramiding of prices. The time had arrived for calling a halt, and by some means, either economic pressure or regulation, to eliminate the abuses and thus force a reduction in the cost to the consumer. There was some reason for hoping that the publicity resulting from the Commission's findings might bring about this result. But now comes an increase in the miners' wages, in spite of the index figure for their existing wages being well above that of the increase in cost of living.

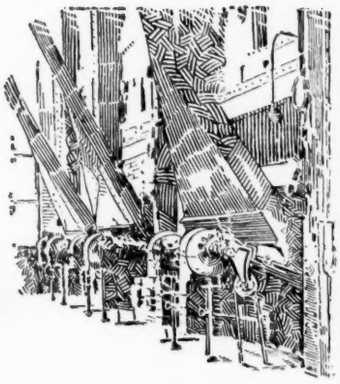
To what extent the added labor cost will be absorbed by the operators, railways, wholesalers and retailers, as urged by Governor Pinchot, is a matter of conjecture. A portion of it at least is likely to fall on the shoulders of the consumer. In any event it will afford the coal industry an alibi in combating any reductions that might be attempted as a result of the Coal Commission's reports.

But this is not all; next spring the soft-coal miners' contract will expire and unless they are accorded treatment at least equal to that which the anthracite miners received there is likely to be trouble in those fields. And so the process goes on, headed toward another period of inflation without a sound economic solution of the problem.

Boston has advanced the idea that the discarded lubricating oil from automobiles be added to fuel oil and burned under boilers. The genius with his sharpened pencils figures that there are fifteen million quarts of this oil wasted yearly, which, if burned, would replace fifteen thousand tons of coal. No doubt lubricating oil could be so used, but why not reclaim it for re-use in the automobile? Oil does not loose its lubricating qualities by use. The object of draining a crankcase is to rid the engine of the mixture of oil, dirt and gasoline drip. By proper filtering to remove the dirt and heating to vaporize the gas content, the lubricating qualities of the oil are again available.



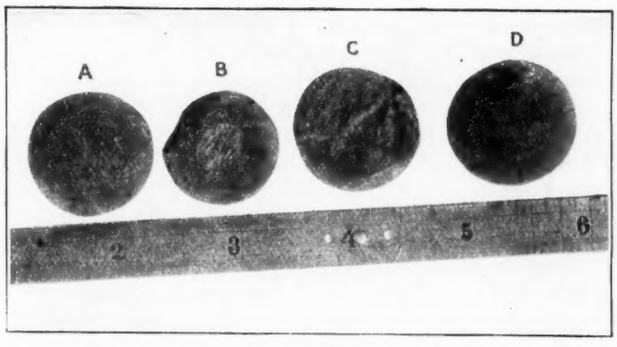
Practical Ideas *from* Practical Men



Unusual Boiler Scale

On opening up one of our 2,500-sq.ft. water-tube boilers for semi-annual cleaning of the tubes with a turbine cleaner, we found a number of rather hard brown balls about an inch in diameter chiefly in the back header, in addition to about $\frac{1}{16}$-in. of a rather soft pinkish-brown scale on the tubes and some loose scale in the tubes and headers. The balls, as shown in the photograph, are quite round and nearly of the same size. They are about the color of a coffee bean, slightly mottled with a lighter brown. The largest one *D* weighed 300 grains, making the specific gravity about 1.6. The view *C* shows one of the balls broken across and shows how it is built up of concentric layers. The one at *B* was cut in half, ground smooth and then brushed to bring up alternate hard and soft spots. It shows a core that looks like a flat piece of scale that had started rolling and accumulated into layers.

The boilers in which these were found are fired with



BALLS OF SCALE FOUND IN REAR HEADER OF BOILER

underfeed stokers and operate under a steady load of about 125 to 150 per cent rating continuously six days a week. The feed water is taken from the New Haven city supply, which is reasonably pure and seldom shows much mud or discoloration. The water is heated to about 180 to 200 deg. F. in an open heater and treated with about 1 lb. of soda ash to 4,000 gal. of water, which seems to prevent the formation of a hard or closely adherent scale.

The regular cleaning routine is to turbine the boiler tubes twice a year and between these cleanings wash down the headers and lower tubes with a fire hose about every six weeks, in addition to blowing down one gage daily, which has proved satisfactory in keeping tube renewals down to less than twenty-five on four boilers in three years, some of the boilers being twelve years old with many of the original tubes. The balls were first noticed about January, 1923, when the boilers were opened up for washing, being at that time about the size of large peas. Most of them were removed, and it was not until the boilers were opened up in May for turbining that the large balls as described were found, being apparently some of the original ones that had not been washed out and had grown continuously.

Reciprocating engines exhaust into the line from which the steam enters the feed-water heater, and at times the boilers have shown a trace of oil at the water line in the drum, but never in any considerable quantity, and the balls themselves are by no means oily.

It will be interesting to hear from readers who have had a similar experience or can account for such a formation.

H. D. FISHER.

New Haven, Conn.

Locating Trouble on an Elevator

Some years ago the writer was required to overhaul an automatic push-button type elevator that had failed to operate. At first sight the job appeared to be simple, but by the time the fuses had been found all right, solenoid switches making proper contact and everything else apparently in order it began to appear differently. The motor was disconnected, tested and found to be in working order. As a next step all the wiring was tested for continuity with a megger and nothing found wrong. The current was then switched on, the solenoid switch blocked in and a lamp placed across the disconnected motor leads; the lamp lighted and it was thought that this was the end of the matter, and that in the disconnecting and testing that had been done previously a bad connection had been made good.

The motor was connected up again and the switches closed with no result. The lamp was placed across the motor terminals but this time it did not light. The motor was again disconnected and the lamp placed across the leads, when it came up to full brilliancy. This deepened the mystery but something had to be done, so it was decided to connect the motor up, leave the switches closed and test back along the circuit with the test lamp on every available point. The up- and down-motion solenoid switches, which were single pole, were mounted on a slate panel together with a solenoid-operated starting resistance having its contacts on the front of the panel and the resistance at the back.

One of the lamp leads was connected to the line motor terminal and the other gradually worked back on the switchboard terminals until all had been tried with no result. The lead was then carried over to the back of the board and tried on the resistance terminals with the

same result. The job was just about to be given up and someone else asked to have a try at it when one more terminal was seen that had not been tried, this was the one connecting the other main lead through the panel to the moving contact of the resistance and on placing the lamp lead here the lamp lighted.

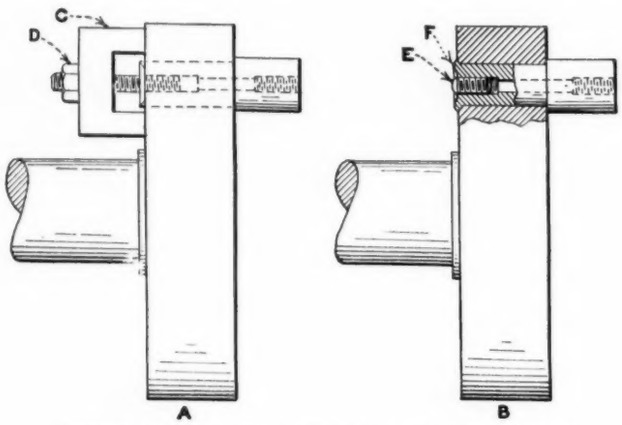
The wire on this terminal was disconnected and the brass bolt that ran through to the front of the panel turned to screw it out when it came away on the first turn. It was found burnt into and the slag thus formed was enough of a conductor to carry the current necessary to light the lamp, but with the motor in circuit it heated up and passed no current. A new bolt remedied the defect and the lift was once more in service.

London, England. M. HARMON.

Fitting a New Crankpin in an Air-Compressor Disk

Some time ago our two-stage cross-compound air compressor developed a knock, and despite any adjustment we could make, the knock would continue. The main bearings and crankpin were keyed up, also the wristpin, and even the shoes on the crosshead were taken up, but it would develop the same pound though at times it ran quietly.

Shortly after the knock developed, it became necessary to put a new piston on the high-pressure side, and in stripping down that side, we discovered that the crankpin was loose in the disk and could be moved by hand. Having a shop of our own, we decided to make a new pin with a drawing fit and put it into the disk cold. The pin was made as shown at *A*, with the small end bored out so it could be riveted over after it was in place in the disk. The hole used for oiling through



SHOWS METHOD OF INSTALLING AND SECURING PIN IN DISK

the center of the pin was drilled through and tapped at each end as shown. After the hole in the disk had been reamed out and carefully calipered to get the right fit, the drawing-in bolt was screwed into the end of the pin, and with the aid of the yoke *C* and the nut *D* the pin was drawn into place in the disk.

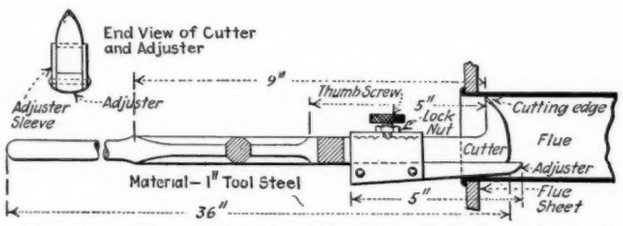
The view *B* shows how the pin was riveted over after being drawn through the disk. The drawing-in bolt was sawed off and riveted over as at *E*. This was done to keep the oil from coming through the pin. This job required the labor of two men about six hours, which was much less time than would have been necessary had the pin been made in an outside shop. It is not always an easy matter to put a crankpin in hot, and care must be taken not to warp the disk when heating it up. When the pin is installed with the disk cold, the compressor does not require dismantling and this considerably reduces the cost of repair. Also, if at any future time it is desired to renew the pin, it is only necessary to cut the rivet burr off the end and knock out the pin, then ream out the hole or bore it out true and make a new pin to fit. R. A. CULTRA.

Cambridge, Mass.

An Improvised Boiler Flue Cutter

At times a regular flue cutter is not obtainable upon short notice in case of a hurry-up job; also, the price of a good cutter may be considered too much to invest in a tool that may seldom be used.

In a few cases I have used a home-made tool of the design shown in the cut and have found it very successful. I have used it on the smaller-sized tubes, but I can see no reason why larger and heavier tubes cannot be cut by using a similar device of heavier design.



TOOL IS ADJUSTABLE TO COMPENSATE FOR EXCESSIVE ROLLING

The tool is forged from 1-in. octagon tool steel. A study of the sketch will show the method of construction, which is quite simple. It is best to forge the tool to an oversize and grind it to an accurate fit for the particular size of tube to be extracted. The purpose of the adjuster is for setting the tool to compensate for excessive rolling. For ease in operation each size of tube to be cut requires a separate size of tool.

To operate, insert the end of the tool into the end of the tube as shown. The adjuster is moved until a close fit is obtained between the tool and the tube; then the adjuster is locked in this position. By forcing the handle down, the cutting edge of the tool is made to pierce the tube wall, cutting an oblong hole the size of which depends upon the amount the cutting edge is forced into the metal. Lift the handle and rotate the tool so that another cut will lap into the preceding one. This process is repeated until the entire periphery is cut through. The cutting edge should be tempered so that frequent sharpening will not be necessary. The tool has certain disadvantages in close places, but it will be found that it can be made to work in most of them. It is obvious that it will not work through a water-leg.

After a little experience with this cutter the work can be done quickly. H. A. ROSE.

Manhattan, Kan.

Where curved-vane forced-draft fans are employed, the vanes should be cleaned out freqently, as they collect considerable dust, especially if the fan is located where any steam is discharged into the air. Dust-clogged vanes not only decrease the capacity of the fan, but in some cases may cause it to become unbalanced. The dust is readily removed with a steam lance.

old with many of the original tubes. The balls were the board and tried on the resistance terminals with the

Comments from Readers

Catalogs and Advertising for the Boys

We are much interested in the article by "Mr. Terry," in the Aug. 14 issue, and have never yet seen the subject handled so accurately as Mr. Terry has done.

It is quite true that many concerns hesitate to pass out expensive catalogs of their product unless an order is directly in sight. There are, however, concerns of long business experience that realize how soon a boy just out of school is likely to assume a position of responsibility, where a knowledge of their goods is mutually valuable. For this reason we invite those who are interested in boilers to send for our printed matter, and we will, with pleasure, place their names on our mailing list for such printed matter as we may issue from time to time.

It is unfortunate, however, that in so many cases catalogs sent to engineers at their places of business are either thrown in the waste basket or placed in files where they are never seen again. If those who desire catalogs for their own personal reference would give their house address there would not be so many complaints regarding lack of attention to inquiries of this nature.

A. C. LIPPINCOTT,
E. Keeler Company.

New York City, N. Y.

Sulphur as a Factor in Flue-Gas Analysis

In an article on "How Sulphur in Fuel Affects Flue-Gas Composition and Computations" which appeared in the July 17 issue of *Power*, C. Harold Berry concludes that "the effect of sulphur on the gas analysis and computation is small, and may be neglected except in refined tests with coal containing a high percentage of sulphur." Mr. Berry elaborates his theme in a longer article in the same issue and shows how some of the sulphur will pass out unburned with the clinkers and how some of the sulphur dioxide will dissolve in the water of the gas analyzer, so that the net amount of sulphur dioxide actually measured along with the carbon dioxide in the analysis would be considerably less than expected.

From Mr. Berry's very thorough treatment of the subject, it would seem that there is hardly anything left to be said, but I believe there are one or two additional points worth mentioning. These points were very forcibly brought to my attention during some work on an SO_2 recorder recently developed. The first point is that rubber soaks up SO_2 just as a sponge absorbs water. In fact, in our earlier experiments, our SO_2 readings were about half of the actual percentages due to the fact that about half of the SO_2 was absorbed from the gas in a one-foot length of rubber tube through which the gas passed on its way to the analyzer. This teaches us that in taking Orsat samples of flue gas through rubber tubing or in automatic recorders which employ rubber connections, the SO_2 will be largely eliminated through this cause alone. Rubber tube connections are not to be recommended, however, for use with CO_2 recorders because of the likelihood of leaks due to the rapid deterioration of such tubing in the presence of SO_2.

In reading the part of Mr. Berry's article that referred to the absorption of SO_2 in the water of the gas analyzer, the reader may have wondered what effect the SO_2 would have in dry-type machines, that is in those CO_2 recorders which employ a dry cartridge for absorbing the CO_2. As a matter of fact, most of the SO_2 will have been removed long before the gas reaches the recorder, as I believe I can show conclusively. Water has a tremendous affinity for SO_2. According to the "Smithonian Tables" one cubic foot of water at 32 deg. F. will absorb 80 cu.ft. of SO_2. At 70 deg. F., which is nearer to the average indoor temperature, one cubic foot of water will absorb 38 cu.ft. of SO_2. This absorption is surprisingly rapid, as can be seen by inverting a bell of SO_2 over water, whereupon the water will be drawn up rapidly into the bell to replace the SO_2 absorbed. The water condensed in the gas-sampling line soaks up the SO_2 with equal rapidity as can be noted by the acid nature of the water dripping from the gas line drain seals.

In order to determine the volume of water condensed, we will first determine, as indicated in the accompanying table, the amount of water vapor produced, from the figures in Table I of Mr. Berry's second article, revised to show the relative volumes of each element while the gases are still hot, that is before the condensation of the water vapor.

Element	Lb. per Lb. Coal	Lb. Oxygen Required	Product	Lb. per Lb. Coal	Mol. Wgt.	Relative Volume	Per Cent by Volume
C	0.70	1.867	CO_2	2.567	44	0.0583	15.44
H_2	0.05	0.400	H_2O	0.450	18	0.025	6.62
S	0.01	0.010	SO_2	0.020	64	0.000313	0.083
Excess Oxygen			O_2	0.221	32	0.00691	1.83
Nitrogen from air and coal			N_2	8.037	28	0.287	76.02
						0.377523	99.993

At 70 deg. the gas would be saturated with about 2.50 per cent water vapor, by volume, hence the surplus water vapor that would condense out would be about 4¼ per cent of the total volume of gases produced. How much would this vapor represent in volume when condensed? We have the rule that one cubic foot (1,728 cu.in.) of steam at atmospheric pressure condenses to about one cubic inch of water, a shrinkage to about $\frac{1}{1,728}$ of the original volume.

The relative proportions of SO_2 and original vapor are 0.083 and 6.62, hence the relative proportions, by volume, of SO_2 and condensed vapor are 0.083 and $\frac{4.25}{1,728} = 0.0025$. In the above illustration 0.083 is only about 33 times as great a volume as 0.00253, hence it is safe to assume that the condensed water in the sampling line would absorb all of the SO_2 present in the above example and even more, as the water is capable of absorbing 38 volumes at the assumed temperature.

Bearing the above facts in mind in conjunction with those presented by Mr. Berry, it is more than likely that the water constantly condensing in the gas line will pick up most of the SO_3, and the trace that may be left will expend itself largely in corroding any metal surfaces with which it may come in contact, unless the gas is dried before analysis. I fully agree with Mr. Berry that for all ordinary fuels the effects of sulphur may be ignored so far as the volumetric relation of flue-gas constituents is concerned. In fact, in practice, the only thought that need be given to sulphur is how to check its corrosive tendencies.

There is another sulphur compound present in flue gas, known as sulphuric-acid fog. This corrosive compound is not very well known because it forms only in very minute quantities and, strangely, it is not readily absorbed by water, like SO_3. It forms, however, a very objectionable deposit on all kinds of surfaces, both metallic and glass. In automatic flue-gas analysis this sulphur compound may be removed in a very simple manner, but when not eliminated often causes serious trouble.

F. F. UEHLING.

New York City.

Large Diesel Engines

In an editorial in the Sept. 11 issue, entitled "Oil Engines of Large Powers," the statement is made, "Granted that Diesel engines of from 6,000 to 12,000 hp. are possible, etc."

In this connection I wish to state that Burmeister & Wain, Ltd., Copenhagen, at present are building two six-cylinder 6,500-b.hp. four-stroke-cycle double-acting Diesel engines. This machinery is on an order from the Swedish-American Line for a transatlantic liner that is to be run between Gothenburg and New York; the vessel is ordered for delivery September, 1924. The auxiliary machinery consists of Diesel-generator units totaling 3,150 brake horsepower.

Furthermore, we are prepared to build this type of Diesel engine in eight-cylinder units of 9,200 b.hp. at 125 r.p.m. The fuel consumption is guaranteed not to exceed 0.38 lb. per b.hp.-hr. A single-cylinder unit has been running under official test continuously for 30 days and develops 1,150 brake horsepower.

From the foregoing you will see that there is no question about the possibility of a 6,000-b.hp. Diesel motor.

H. C. HASTINGS,
Burmeister & Wain, Ltd.

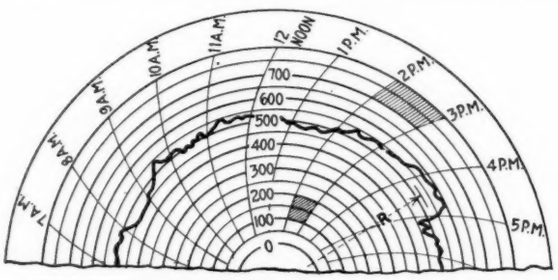
New York City.

Planimeter Used for Averaging Charts from Recording Instruments

Referring to the article, "Planimeter Used for Averaging Charts from Recording Instruments," in the July 31 issue, the delusion still seems to persist that the true average value of a varying line traced by a pen on a circular chart can be obtained by measuring the area inclosed by the line. In the March 3, 1908, issue of *Power* A. V. Youens precipitated a lively discussion by making the same statement and illustrating its application with an ordinary polar planimeter. There immediately followed replies, some of which were of an elaborate nature, calling attention to the fundamental error of assuming that the average radius on a circular chart is proportional to the square root of the mean value of the squares of the radii; for instance, see the March 23, March 31 and April 28, 1908, issues of *Power*. The controversy was renewed again in the Aug. 19 and Oct. 21, 1908, issues.

Referring to the chart shown in the article of July 31, the error of the method suggested [that is, average reading $= (0.565\sqrt{A} - r)K$] is obvious if we compare the area represented by an increase of 100 from 100 to 200 on the chart and that of the same increase from 700 to 800, as shown by the shaded portion in the illustration.

In other words, a planimeter measuring areas applied to this chart would give a much greater reading for the latter, and hence such an instrument cannot



SHOWS CORRESPONDING AREAS AT DIFFERENT LOCATIONS ON CHART

be used to average accurately radial distances from zero. It is a fact that if the charted line lies within a narrow zone, the area method is often of sufficient practical accuracy, but when employed its limitations must be recognized. Special planimeters are on the market which can be correctly used on circular charts; their reading is directly proportional to average radial distance multiplied by circumferential movement; hence the average radial distance equals planimeter reading multiplied by a constant.

C. G. RICHARDSON.

Providence, R. I.

[Strictly speaking, Mr. Richardson is right in his contention that the true average value of a varying line on a circular chart cannot be obtained by measuring the area inclosed by the line. A similar contribution has been received from N. T. Peeff, Indianapolis, Ind.—Editor.]

Why Not More Poppet-Valve Engines in America?

In the Aug. 14 issue of *Power*, G. A. Joerger makes a plea for the more extensive use of the poppet-type of valve in this country and with the most of it I heartily agree, but am constrained, in the interest of truth, to question his statement to the effect that "the first poppet-valve engine" was built by Sulzer Brothers of Switzerland, in 1865. Possibly I may be in error about this matter, but in my first "Reminiscences of a Veteran Mechanical Engineer" published in the June 19 issue of *Power*, I refer to having first met Mr. William Wright while running a Woodruff & Beach engine while Mr. Wright was superintendent of works.

This engine had poppet-type admission valves and slide valve for exhaust. The date of this meeting with Mr. Wright was about 1869 (as an old log book shows) and as this Woodruff & Beach engine had been in use several years before I took charge of it, and made my first record-breaking venture in the "Economical Generation and Application of Steam," as my letter-heads had it, I have reason, apparently, to suppose that the poppet-type of valve was in general use in our country long

before the date given by Mr. Joerger. Also as the Pacific Mail steamships, built at the Novelty Iron Works, and to which I refer in my article, were fitted with this type of valve, as well as about all our river and harbor side-wheel boats, possibly my conclusions are correct.

Please understand this is written in no carping spirit, but only to try to set right a historical fact for the guidance of those who come after us old fellows, who "did our bit" in our youth. W. H. ODELL.

Brooklyn, N. Y.

Dual Clearance Unaflow Engine

The letter by Duncan A. Morton on the "Dual Clearance Unaflow Engine," in *Power*, Aug. 21, 1923, is interesting, and impresses the writer with the thought that many points concerning this engine were not clearly brought out in the article in *Power*, July 17, 1923.

In the language of Mr. Morton we affirm that, "the dual clearance pipe used in the Harrisburg engine is not only a substitute for the extra clearance spaces in the cylinder head and for the auxiliary exhaust valves, but is a novel and efficient means of avoiding the objectionable features of both these methods for preventing excessive compression in unaflow engine cylinders when working non-condensing."

The dual clearance principle is particularly adaptable to non-condensing conditions but can also be used for condensing. The letter, of July 17, 1923, explains that the act of changing from one condition to the other can be accomplished instantly without stopping the engine and without changing the valve.

This is to contradict the statement in *Power*, Dec. 26, 1922, that "to change to non-condensing operation requires the readjustment of the valve, a matter of one or two hours' shutdown."

The clearance of the engine referred to July 17, 1923, was about 5 per cent condensing and about 12 per cent non-condensing. Steam pressure 105 lb. gage.

Had this been a pure Stumpf unaflow engine, the non-condensing clearance would have been nearly 28 per cent, because of the low initial pressure.

Professor Stumpf in his second edition 1922, "The Una-flow Steam Engine," page 48, gives a table of the total amount of clearance volume required when operating non-condensing, for 90 per cent length of compression. This is reproduced with the added correction of gage pressure.

Initial pressure, atmosphere, absolute	8	9	10	11	12	13	14	15	16
Approx. gage press.	105	120	135	150	165	180	195	210	225
Total clearance per cent	27.9	23.8	21.3	19.2	17.6	16.25	15.15	14.2	13.4

The use of the dual clearance principle permits a possible reduction of these clearance volumes of from 60 to 75 per cent, and avoids the counterflow action of the exhaust, which must take place in engines with auxiliary exhaust valves. It also eliminates the possibility of leakage through the exhaust valves because it has no exhaust valves.

Professor Stumpf in commenting on this engine in his new book says the engine "is of special interest," and that "the unaflow principle is fully adhered to, since the exhaust steam leaves only through the central exhaust ports. The series arrangement of live steam, inlet valve, piston and exhaust is also retained, so that any leakage of steam past the piston valve cannot directly pass to the exhaust. The effect of this dual clearance principle is to raise the expansion line and lower the compression line, consequently the mean effective pressure output and uniformity of speed are somewhat increased and the necessary flywheel weight is decreased."

The preceding remarks should be a satisfactory answer to the question asked, "of what service is the dual clearance?" but in addition there are several other things.

Those of most importance are, the full thermal advantage of the Stumpf unaflow engine, the simplicity of construction, as a single valve will accomplish the work of four, and remarkable steam consumption.

When there are no facilities for condensing, the dual clearance engine is especially suited for the conditions as it retains all the fundamental features of the true unaflow engine, gives at least equal economy with the four-valve engine with central exhaust ports, without complication of parts. If the engine must be operated a part of the time condensing, provision is made to obtain the necessary clearance for non-condensing by adding pockets for that purpose as mentioned in the letter referred to.

It is agreed that, "large clearance volume is incompatible with low steam consumption," especially for condensing engines.

With this principle so well established the pure Stumpf unaflow engine is the only type to use when the last word in economy is desired and condensing facilities are available.

The pure Stumpf unaflow engine can be built with any type of admission valves, has no exhaust valves and does not need the dual clearance. As clearance surfaces are as detrimental to economy as clearance volume in condensing engines, these are reduced to the limit. Since every condensing unaflow engine may have to run non-condensing at times, this engine must also be provided with clearance pockets for non-condensing if needed.

A description of the condensing type of unaflow engine, mentioned in these articles, will soon be published, but as an illustration of its advantages, the information that an engine of this type gave exceptional results under ordinary conditions will be of interest.

BENJ. T. ALLEN, Chief Engineer,
Harrisburg Foundry & Machine Works.

Harrisburg, Pa.

The common types of steam traps may be listed under four headings: Expansion or thermostatic traps; tilting traps; closed float traps; and open-float or bucket traps. In the thermostatic trap the expansion of metal or a contrivance of metal, generally termed the expanding element, is depended on to operate the valve. In the tilting trap the body or receiver is suspended on hollow trunnions that form the ports of entry and discharge for the condensation that the trap handles. As the receiver drops after filling, it operates the trap valve and then closes this valve as it rises after discharging, being actuated by a counterweight. In the closed-float type the buoyant effect of a float is applied through a system of levers to operate the valve in opening, and the weight of the float is used in closing. In the open-float or bucket trap the weight of the full bucket is used to operate the valve in opening, but its buoyancy, after the bucket is emptied, is utilized in closing.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Rusting Fast of Lock Nuts

Each winter when we overhaul our ice machines it is found difficult to unscrew the lock nuts that hold the valves in place. What can be done to prevent this trouble? H. L.

Before setting up lock nuts it generally is good practice to coat the screw threads of the bolts or studs with a dope of ordinary pulverized graphite and enough heavy cylinder oil to form a thick paste. This will prevent rusting and permit the nuts to be unscrewed after some time, by application of only a little more force than was used for setting them in place.

Percentages of Coal Mixture and Cost Per Ton

Our fuel consists of screenings costing $4 per ton and soft coal at $8.32 per ton, mixed in a barrow holding 300 lb., made up of 6 shovelfuls of screenings and 8 of soft coal. What per cent of each is burned and what is the cost per ton of the mixture? P. E. M.

Assuming that there is the same weight per shovelful of each kind of fuel, if a barrowful, consisting of 300 lb. or any other quantity, is made up of 6 measures of screenings and 8 measures of coal, or a total of 14 measures, then $6/14 = 0.428$ or 42.8 per cent would be screenings; and $8/14 = 0.571$ or 57.1 per cent would be coal, and the cost of the mixture would be (42.8 per cent of $4) + (57.1 per cent of $8.32) = $6.46 per ton.

Water-Column Piping

What should be the size of the water-column connections for a horizontal return-tubular boiler? W. L. C.

The least size of pipe and connections should be 1 in., with the steam connection taken independently from the top of the boiler shell or upper part of the head, and the water connection taken from a point not less than six inches below the center line of the shell. For a power boiler the water connections to the water column should be of brass and made up with plugged cross-fittings to facilitate cleaning, and should be fitted with a drain cock or valve with suitable connection to the ashpit or other safe point of waste. The water column blowoff pipe should be at least ¾ in. in diameter.

Cause of Pump Becoming Steam-Bound

What causes the water end of a boiler-feed pump to become steam-bound when the water is not warm enough for steam to rise from the surface of the water when exposed to the atmosphere? J. C. A.

The boiling point, or temperature at which water becomes converted into steam, depends on the pressure. At atmospheric pressure the temperature is 212 deg. F., and at lower pressures steam is formed at lower temperatures until at the pressure of 0.0886 lb. per sq.in. absolute, or about 14.6 lb. per sq.in. less than atmospheric pressure at sea level, the boiling point is close to 32 deg. F., which is the freezing temperature of water. Hence, when the suction water for a pump is not supplied under sufficient pressure to prevent lowering of the pressure to that pressure whose boiling point is the temperature of the water, steam is liberated from the water and the pump becomes "steam-bound."

Tubes Too Short for Buckled Tube Sheet

In re-tubing a return-tubular boiler, why should the last tubes to be inserted be found too short? H. F.

The order may have been based on measurement taken for length of tubes required near the periphery of the tube sheet, and the last tubes to be inserted nearer the center were found too short due to one or both of the tube sheets being buckled outward previous to the re-tubing; or the buckling may have been caused by first expanding the outer tubes and working towards the center of the tube sheet. The trouble would be obviated by setting a tube near the center of the boiler and next setting four or five equally spaced tubes each about half way between the center and periphery of the tube sheet.

Preferential Use of Small Pump Valves

Why is a large number of small valves used in a pump in place of a few large valves? C. T.C.

A number of small valves is preferable to a few large valves, as smaller valves are cheaper in construction, easier to repair or replace, and the same combined discharge capacity is obtained with less lift, and quieter action is obtained when the pump is working at its highest speed. This will be understood when it is taken into consideration that although the area for flow of water through the valve seat has to do with the area, which increases with the square of the diameter, the lift for escape of water under the valve to the chamber into which the water is to flow, has to do with the circumference only, which varies directly as the diameter. Thus, neglecting the obstruction by the grids, one 9-in. diameter valve would have an area of 63.62 sq.in. and circumference of 28.27 in. and the lift required to make the circumferential opening equal to the area would have to be $63.62 \div 28.27 = 2.25$ in. The same valve area would be obtained with four valves, 4½ in. diam., but the combined circumference would be $14.14 \times 4 = 56.56$ in. and to obtain a circumferential area equal to the combined valve area would require a lift of $63.62 \div 56.56 = 1.125$ in. or only one-half that required by the single valve.

Inequality of Cutoff from Angularity of Connecting Rod

In a slide-valve engine what effect has angularity of the connecting rod on the equality of the cutoff?

W. B. S.

On account of the angularity of the connecting rod, more degrees of rotation of the shaft are accomplished for a fraction of stroke of the piston from the crank end than for the same fraction of stroke from the head end of the cylinder. Hence the eccentric moves the valve farther for a given fraction of stroke from the crank end, and, if the valve is set with equal laps when in its central position, cutoff will occur earlier in a stroke from the crank end of the cylinder. Equalization can be corrected by giving the valve more lap on the head end than on the crank end. But as that reduces the lead on the head end, and some lead is more desirable than equality of the cutoffs, the valve setting should be compromised to favor the leads.

Flow of Water Required to Develop Stated Power

With 20 ft. fall, what flow of a stream would be required, in cubic feet of water per minute, to develop 50 hp. with a turbine water wheel? F. R.

A cubic foot of water at the temperature of 62 deg. F. weighs 62.36 lb., and for each cubic foot of water flowing per minute with a fall of one foot there is development of 62.36 ft.lb. per minute, which is at the rate of $62.36 \div 33{,}000 = 0.00189$ hp. However, in development of a water power, some of the natural head and fall must be sacrificed for getting the water to and from the water wheel, and the power then realized depends on the per cent of efficiency of the turbine when operating under the stated working conditions. Assuming that with development of 20 ft. natural fall there is an actual working head of 18 ft. and the efficiency of the turbine is 80 per cent, for each cubic foot of stream flow the power realized would be $0.00189 \times 18 \times 0.80 = 0.027216$ hp., and development of 50 actual hp. would require a stream flow of $50 \div 0.027216 = 1{,}837$ cu.ft. of water per min.

Impairment of Flue-Gas Analysis from Change of Temperature and Contact with Water

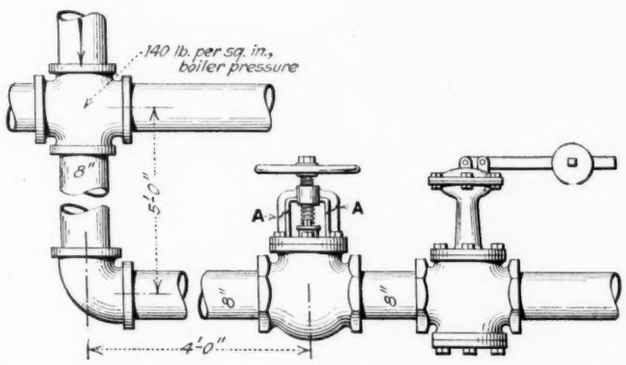
In flue-gas analysis what effect has a change of temperature of the sample on the percentage of CO_2, CO and O, and how are the percentages affected by contact of the gases with water? H. W. K.

The coefficient of volumetric expansion or contraction of the principal constituent is practically the same for each of the gases within the ranges of pressures and temperatures at which flue-gas analyses are conducted, and their relative percentages may be considered as unchanged by a change from the original temperature or the small variation of temperature of the sample during manipulation of the apparatus. A change of 2 deg. F. of temperature makes a difference of only 0.4 of one per cent in the volume, and a change of 0.1 in barometric pressure changes the gas volume by only 0.3 of one per cent.

Absorption of the gases by water is different for each, depending on temperature, pressure, time of exposure and degree of saturation of the water with which the gas may be brought into contact. However, in flue-gas analysis error from absorption by water in the apparatus is eliminated by employment of aspirating apparatus in which the first sample taken in is used to saturate the water. When the second sample is taken in, the water will not absorb any more of the gases, and the sample will be just as it was in the flue. When an Orsat apparatus is first set up one or two blank analyses are sufficient for saturation of the water of the leveling bottle.

Breakage of Valve Yoke with Lowering of Pressure

What would cause breakage of the yoke of an 8-in. globe stop-valve in a steam line as shown in the sketch? This valve, after being closed three months, suddenly broke at the points of fracture *AA*. The



FRACTURE OF VALVE YOKE AFTER REDUCTION OF PRESSURE

regular working pressure is 140 lb. gage. The break occurred at 4 a.m., when the boiler pressure was only 60 lb. and no steam was being used for any purpose. How should the inlet and outlet of such a valve be placed with respect to the direction of flow? R. W.

From the conditions stated, it would seem most probable that, as a result of setting the valve down hard when cold, the yoke became fractured, or at least severely overstressed from expansion, or upward movement of the stem, whenever the valve became heated. Also, it is to be noted from the sketch that there is no special provision for drainage of condensate, and with the valve already set down so hard as to endanger the yoke to rupture, the remaining strength may have been overcome by water hammer which might be as violent at one pressure as at another. Or, with the valve already set down hard and the yoke stressed nearly to its breaking point, a reduction of the pressure and temperature might have been accompanied by contraction of the body of the valve, or other change of form, that carried the valve seat and valve upward with enough additional force to stress the yoke to the breaking point.

With regard to the manner of setting, a globe valve should be so set in the line that when the valve is closed the greater pressure will tend to move the disk away from its seat or, as commonly expressed, so that pressure will be on the under side of the valve. Otherwise, for opening the valve, the operator must overcome the difference of pressure over the whole area of the valve aperture, and there is danger of pulling the disk from the stem and rendering the valve inoperative.

Easy Lessons in Engineering

The Meaning of CO_2

Constant use has made "CO_2" the chemical formula for carbon dioxide, familiar to all power-plant operatives. It is universally agreed that a high percentage of CO_2 in the flue gas generally goes with high boiler efficiency and is therefore desirable. The reason for this is not always so clearly understood, so it will be worth while to go into the matter a little.

Combustion is a chemical reaction in which various substances having a natural affinity (attraction) for oxygen unite with it, automatically giving off large amounts of heat. In ordinary combustion problems only three combustible elements of any importance occur. These are carbon, hydrogen and sulphur. The chemical symbol C stands for one atom of carbon, H for one atom of hydrogen, S for one atom of sulphur and O for one atom of oxygen. The symbol CO_2 means that one molecule of carbon dioxide contains one atom of carbon and two of oxygen. It is the substance formed by the complete combustion of carbon according to the chemical equation, $C + O_2 \rightarrow CO_2$.

While coal contains a noticeable amount of hydrogen and a little sulphur, the chief combustible element is carbon. For a preliminary study of CO_2 we may assume that the coal contains nothing but carbon, ash and moisture.

Then when such a fuel is completely burned, 3.67 lb.[1] of CO_2 gas is produced for each pound of carbon contained.

While this weight relationship is important in many combustion problems, the volume relationship is more important in understanding the significance of CO_2 percentage, which is generally understood to mean the percentage of CO_2 by volume in the flue gas.

At a given temperature and pressure a molecule of any gas occupies the same space as a molecule of any other gas (this does not apply to vapors or solids). So the volume of each gas is proportional to the number of its molecules. The formula $C + O_2 \rightarrow CO_2$ shows that it takes one molecule of O_2 to make one of CO_2. Hence, when a certain volume of oxygen unites with carbon, the volume of CO_2 produced must exactly equal the volume of oxygen that disappears.

To burn the fuel we do not supply pure oxygen, but air which is a mixture containing approximately 21 parts by volume of oxygen and 79 parts of the dead gas nitrogen (N_2). The nitrogen is merely carried along and heated up, but undergoes no chemical change.

Starting with 100 parts of air, we have 21 parts of O_2 and 79 parts of N_2. If just enough air is supplied to burn the carbon, all the O_2 will disappear to form the same volume of CO_2, so that the flue gas will contain 21 parts of CO_2 (by volume) and 79 parts of N_2. Therefore, with pure carbon as a fuel, a flue-gas analysis of 21 per cent CO_2 and 79 per cent N_2 would show perfect combustion without excess air. If twice as much air as needed were furnished, only half of the oxygen would change to CO_2, giving a flue-gas analysis as follows: 10½ per cent CO_2, 10½ per cent O_2, 79 per cent N_2. If three times the necessary air were furnished, out of 100 parts of air only 7 parts of oxygen ($\frac{1}{3} \times 21$) would burn, giving 7 parts of CO_2 and leaving $21 - 7 = 14$ parts of O_2 and 79 parts of N_2, so the flue-gas analysis would be: CO_2, 7 per cent; O_2, 14 per cent; N_2, 79 per cent.

In each case the combustion was assumed to be complete. Low CO_2 does not indicate incomplete combustion, nor does excess air of itself cause any loss. That is, excess air would cause no loss if all the heat were abstracted from the gases by cooling them to room temperature before discharging to the stack. Practically, they must be thrown away at a temperature ranging from 300 to 700 deg. The resulting loss is simply that due to "heating up the sky" with a lot of hot gas. The amount of the loss is proportional to the weight of flue gas and its "temperature difference" (the temperature elevation above that of the room).

Therefore it is important to keep the total amount of flue gas per pound of coal at a minimum; that is, to use as little excess air as possible without getting imperfect combustion (indicated by presence of CO).

To figure the flue loss for any actual case, it will first be convenient to find the percentage loss per degree of temperature difference with no excess air. The theoretical air required to burn one pound of carbon is 11.52 lb. and the corresponding weight of flue gas is $11.52 + 1 = 12.52$. lb. To heat one pound of flue gas one degree takes 0.24 B.t.u., so the heat for 12.52 lb. will be $12.52 \times 0.24 = 3$ B.t.u.

The pound of carbon has a heating value of 14,600 B.t.u., so the percentage loss is $\frac{100 \times 3}{14{,}600} = 0.0206$ per cent or, practically, 0.02 per cent. This figure multiplied by the actual temperature difference and the ratio of actual flue gas to theoretical gives the actual per cent loss.

Suppose, for example, that the CO_2 is 8 per cent, the flue temperature 590 deg. and room temperature 70 deg. Then the temperature difference is $590 - 70 = 520$, and the ratio of actual flue gas to that theoretically needed is $\frac{21}{8} = 2.6$. Then the percentage loss in the hot gases is $2.6 \times 520 \times 0.02 = 2.6 \times 10.4 = 27$ per cent.

It should be kept in mind that this method is based on the assumption that the fuel contains no hydrogen and that combustion is complete to CO_2, no CO being present in the flue gas.

[1] The easy lesson in the July 17 issue showed how relative weights are figured.

The Storage of Bituminous Coal*

IT MAY be said that the storage of most grades of bituminous coal is possible and practicable and generally profitable. Public utilities and steel companies have long found it necessary, and other large consumers more and more are finding it desirable. Even railroads, which formerly made no provision for the protection of their coal supply in an emergency, but calmly confiscated what they needed from cars in transit, now find it both good morals and good business to provide their own protection. When the smaller consumers, either by storage on their own premises or in some community coal yard, provide their own storage, traffic congestions and interruptions and periodic coal strikes will lose their terrors. Time will be given for the settlement of labor disputes on their merits, and eventually, it is hoped, coal will be cheaper.

The mines of the State of Illinois in normal years produce about 80,000,000 tons of coal in the twelve months period. The output is the lowest in April and highest in December, the December output being about double that of April, with a gradual increase from month to month during spring and summer and a gradual reduction during January, February and March. This situation has led to the opening up of more mines than are needed to take care of the business, with the result that, taken as a whole, the mines are in operation about half of the working days of the year. Illinois, therefore, has double the number of mines that its market requires and double the number of miners necessary to produce its 80,000,000 tons of coal.

Shut Down Superfluous Coal Mines

This army of miners—with some ground for their actions, it must be admitted—have succeeded in having a rate of pay established that will give them a comfortable annual income for about one thousand hours of work a year. If the poorer mines of the state, comprising one-half of the tonnage, were shut down and their force of miners transferred to other callings, while the remaining miners were given two thousand hours' work a year at a rate of pay comparable with rates paid above ground, there would be an annual saving in cost of coal production amounting to a dollar a ton on 80,000,000 tons in the State of Illinois alone. Similar if not equal savings would be possible throughout most of the bituminous coal fields of the country. This would tend to make an even flow of coal traffic on the railroads the year around, to the great advantage of the railroads, as it would materially increase their tonnage during the season of the year when their business is the lightest and when it could be handled at the lowest expense.

If it were possible to realize for the consumer a reasonable portion of these savings that would result in mining and transportation, there would be a very considerable allowance available to recompense him for the expenses incurred in the storing of coal, which involve: The interest charges on investment during the time the coal is in storage, the cost of handling, the loss of value due to degradation, and the fire risk. We will consider these in the order named.

If a coal storage were accumulated at an even rate during the months of April to August, inclusive, and were consumed during the months of November to March, inclusive, the average period in storage would be seven months, and at an annual rate of 6 per cent interest the capital carrying charge would be 3½ per cent for the period in storage; or with coal costing $5 a ton f.o.b. cars at the storage yard, the interest charge would be 17½ cents on each ton in storage.

The cost of handling coal would, of course, vary with the amount stored and the facilities provided for handling. Many books have been written on this topic, but in general the double cost of storing and reclaiming may be said to vary widely between 12 cents a ton and 75 cents, the lower figure referring to handling in large quantities, using car dumpers, belt conveyors and gantry cranes with 5-yard buckets, while the higher figure is what it might cost to handle coal both ways by shovel and wheelbarrow.

A storage plant for one pile of 200,000 tons or more would have to unload the coal cars with a car dumper and distribute the coal on the pile by a running belt, reclaiming it with a gantry crane. Storage of lesser amounts, down to 25,000 tons, would be conveniently handled by locomotive cranes both into and out of storage. Smaller amounts of coal would be handled by some form of a wagon loader, which would take the coal from the ground as dumped from the car and elevate it into an adjoining pile. Other forms of conveyors, such as drag buckets and pivoted conveyors, are satisfactory and economical when applied to a storage proposition of the proper size and kind. Most of these methods of handling would come under 15 cents a ton each way.

Stored Coal Disintegrates Slowly

The degradation of coal due to weather and handling is an item of some importance, although it is usually much over-rated. Lumps of coal on the surface of a pile will disintegrate and become quite fine, so that the pile will look like a pile of screenings, but six inches below the surface it will be found that the lumps are intact and bright except for some staining, which might result from dissolving out iron and sulphur. If the coal is to be used in a stoker of some kind, which would necessitate its being crushed before using, and particularly if the stoker has forced or induced draft, this disintegration of the surface lumps is of very little consequence. It is commonly supposed that the coal loses heating value if kept long in a pile. This supposition is undoubtedly true, but the loss of heating value is so trivial that laboratory tests and boiler tests frequently give no certain indication of it, and it is doubtful if it exceeds 1 per cent.

There is, however, another species of degradation, which is of more moment. Some kinds of coal when in a finely divided state will absorb a considerable amount of oxygen, which materially changes the nature of the coal, so that it is much slower burning than it was in its natural state. Naturally, a fireman who finds that his steam gage does not respond to his efforts so readily with this coal from storage as it does with the freer burning fresh coal, is likely to insist that the stored coal has "lost its heat," as he expresses it. The coal, in fact, has not lost its heat but, on the contrary, is reluctant to give it up, and although the burning may be at a little slower rate, the evaporation of water per pound of coal will be about the same.

Anyone who in the course of a month has seen a pile of his stored coal in turn emit steam, gas, smoke, and then show glowing fire at night and has witnessed the futility of attempts to quench this fire by hose streams would necessarily be impressed with the fact that a fire hazard does attend coal-storage undertakings, and he would naturally be prejudiced against repeating the experiment.

There is indeed a certain fire hazard incident to coal storage, and most kinds of coal can be stored so that they will take fire in the pile. On the other hand, it is possible to so store coal that the risk of spontaneous combustion will be reduced to almost nothing. A knowledge of the cause of coal firing spontaneously is fundamental to successful coal storage, and it lies in the chemical nature of coal and its behavior when exposed to the air.

There are certain organic substances that oxidize at normal temperatures, and although we do not recognize it as such, they are as truly burning as though there were a manifestation of smoke and fire. The behavior of linseed oil in air is an illustration of this phenomenon. When this oil is applied to a surface as an ingredient of paint or varnish, it quickly hardens by oxidizing and without any noticeable evolution of heat. This is because the small amount of heat that is evolved is dissipated by absorption or radiation. If a painter uses cotton waste or rags to clean his brushes or to wipe up some oil or varnish that

*From a paper by W. L. Abbott read before the annual convention of the National Association of Stationary Engineers at Buffalo, Sept. 13, 1923.

had spilled and then leaves those rags in a loosely compacted ball, there will be a sufficient supply of air to oxidize the oil, and the heat thus generated will be radiated so slowly from the center of the ball that in a few hours the temperature will rise to a point that will produce smoke and then flames. If the bundle of oil-soaked rags had been dropped down by the side of a hot steam pipe, the time required to produce smoke and flames would have been materially shortened, whereas if it had been thrown out of doors on a cold night it might not have heated at all.

Coal is a very complex body, composed of various compounds which exhibit different characteristics when exposed to the air. There are, in the first place, certain ingredients which are quite fixed in their composition and habits and which will not ignite except under the influence of a temperature close to low red heat. Then there are other substances, smaller in amount fortunately, but which, like one bad potato in a barrel of potatoes, is liable to spoil the whole mass. This is a substance called mineral charcoal, which, like linseed oil, will absorb oxygen when exposed to the air and, if conditions of ventilation and radiation are rightly adjusted, will gradually rise in temperature throughout a period of several days or several weeks, until a temperature is reached at which the warning odor of a pungent gas may be detected—a sure indication that trouble is on the way. This particular ingredient of coal, that absorbs oxygen, is also the troublesome component that renders some grades of bituminous coal non-coking.

Mineral Charcoal Sometimes Present

It is present in large quantities in lignite, in lesser quantities in the more inferior grades of bituminous coal, and proportionally less in the higher bituminous grades, and in the semi-bituminous and anthracite it is practically non-existent. That is why the inferior grades of coal are more liable to fire in storage, but even these grades can be stored with reasonable safety if attention is given to another characteristic, which is that this slow combustion or oxidation takes place almost entirely on exposed surfaces and not in the interior of lumps. Therefore, the amount of heating that may be produced in a given quantity of coal is proportional to the sum of the superficial areas of the various pieces of which that coal pile is formed. A round lump of coal one inch in diameter has a superficial area of a little more than three square inches. This same lump ground into one hundred pieces of equal size will have a superficial area of 300 sq.in. and the amount of heating will be increased one hundred fold.

This gives us the key to successful coal storage, and it is quite simple. Do not put fine coal into the storage pile, and by fine coal I mean pieces that would go through a 1-inch round hole. As a matter of fact, if only the dust that would go through a ¼ in. round hole were removed, the hazard of the remainder getting dangerously warm would be small. In practice it is easier to take for storage lump, egg, or nut coal as it comes from the mine. With such sizes any depth of pile over ten feet is not of much consequence, as the heating, if any, takes place midway up the side of the pile and about five feet in from the surface. If a hot spot should develop it is easier to dig it out than to put it out.

Counterflowing Condensate in Steam-Heating Connections

Engineering Bulletin No. 13, recently issued by the State College of Washington, Pullman, Wash., gives the result of experiments made by William A. Pearl and Eri B. Parker at the Engineering Experiment Station of this institution. The purpose of these experiments was to determine for various pipe sizes, pipe slopes and steam pressures, the maximum rate at which steam could flow to radiators without preventing the continuous return of the condensate through the same pipe. It was felt that the question was of considerable practical importance, as guesswork on this point had frequently led to extravagant habits of design.

Tests were made on vertical, inclined and horizontal pipes, ranging in size from ¾-in. to 2-in., and under pressures ranging from 1 to 6 lb. gage. The critical rate of flow proved to be practically independent of the pressure used. It was observed that this critical rate of flow was not necessarily governed by the pipe size, but rather by the smallest cross-section in the line through which the condensate had to flow. As a result, when the valve used had the same nominal size as the pipes it became the governing factor because of its smaller throat area. The pipe size became the governing factor when the valve was chosen one size larger than the pipe.

The maximum permissible flow increased with the inclination of the pipe until a slope of 1½ in. per 10 ft. was reached. After that it fell off so that the critical flow for a vertical pipe was slightly less than for one with a slope of 1½ in. in 10 ft. Therefore, the figures given in the attached table are substantially correct for any pipe with a slope not less than 1½ in. in 10 ft.

In summing up the results of the experiments, with particular reference to their practical application, the authors state that where noise is objectionable the critical rate of flow must not be exceeded at any time, but where a certain amount of noise is allowable during the period of heating up a room, sizes may be chosen for normal heating conditions.

MAXIMUM PERMISSIBLE PIPE CAPACITY WITH PIPE SLOPE 1½ IN. PER 10 FT.

Nominal Pipe Size	Nominal Valve Size	Permissible Capacity, Lb. per Min.
¾	¾	0.14
¾	1	0.17
1	1	0.34
1	1¼	0.37
1¼	1¼	0.58
1¼	1½	0.74
1½	1½	0.86
1½	2	1.03
2	2	1.53
2	No valve	1.56

Power

By R. Manly Orr

Power is a blessing to all its possessors,
Givers, receivers and mediums too,
Cherished alike by the clowns and professors,
Cause of our joys whether many or few.

Power is the life of the worst and the best of us
Over us, under us, in and around,
Power to the north of us, south, east and west of us,
Power in the water, the air and the ground.

Dynamo, motor, train, boat, plane or flivver,
Man, beast or bird, or the creatures that crawl,
Steam, gas or current, or sun, wind and river,
Power is their pulses, their passion, their all.

Whether in pipe, cable, shaft or conductor,
Power is the purpose and power the desire,
Power is our slave and our boss and instructor.
Light, heat and power in eternity's fire.

Coal, wood and oil for the engine and boiler,
Tides for the burdens of harbor and shore,
Power for reducing the load of the toiler,
Spreading his table and filling his store.

Power for the needle, the pen and the shovel,
Power for the task which we ought to perform,
Power for all needs, both of palace and hovel,
Limitless power, for the ages unborn.

Power in the lightning, the search-light and taper,
Power in the growth of a world full of crops,
Power in the liquid, the solid, the vapor,
Power in the atoms, the flakes and the drops.

Power in the spring-time and power in the autumn,
Power in the swing and the tilt of the earth,
Sweeping its map from the top to the bottom
Fully conserved in a yearly rebirth.

Power overpowering, gigantic, astounding,
Listen! As sure as eternity stands,
Out of God's power house the challenge is sounding,
"Use me to better the state of all lands."

News in the Field of Power

United States Coal Commission Publishes Numerous Reports

Publicity and Co-operation Between Operators and Miners Are the Keynotes for Reform in the Coal Industry

TWO outstanding conclusions and recommendations that will appear in the final report of the United States Coal Commission, will be provision for full publicity from operators and miners alike under government supervision, and that many of the most serious problems confronting coal mining may be worked out by the elements of the industry itself far better than would be the case were legislative bodies to attempt to enact mandatory laws dealing with these subjects.

There occurs in several chapters of the report as thus far made public, the recommendation for publicity—publicity of costs of operation and other factors that concern the operator, and also publicity as to the disposition and source of funds of the United Mine Workers of America. In more than one chapter there has appeared the note that outstanding problems of the industry should be solved by the industry itself, in conference and co-operation between the operators and the miners. In fact, the most serious direct criticism that the Coal Commission has made regarding the union is that the mine workers have devoted so little attention to the solution of problems affecting its membership through constructive study.

The Coal Commission released for publication on September 14 a report giving a summary of its recommendations on "Labor Relations in Bituminous Coal Mining," and followed this on Sept. 17 with an extensive report on this subject. Among the conclusions and recommendations are these: "We do not advocate nationalization as a means of meeting the national strike or other parts of the problem of labor relations"; a check upon provocative publicity; separate and joint study by operators and union of means of stabilization of the industry; provision by Congress for continued study of unemployment; joint commissions in each district and nationally to study mine work and existing rate differentials, and also continued study of this subject by the national government; full publicity and compulsory publicity of rates in the non-union fields; discard of subcontracting; abolition of leasing convicts for mine work; that discounting script be made illegal; discontinuation of use of spies and the use of deputy sheriffs as paid company guards; discontinuing the check-off for collection of fines and special assessments; a continuing umpire in each district; an improved organization of operators, both district and national; opposing compulsory arbitration; stating that incorporation of the unions would not make them any more responsible; an inquiry under authority of the President into points at issue when an agreement is about to expire.

In its full report on labor relations, the commission discusses the check-off at length and draws the conclusion that this system in itself is bad union policy as it tends to make officials of the union lose contact with the membership. While collection of union dues is not directly condemned, the practice of having operators collect fines and special assessments for the union is opposed.

One chapter of its forthcoming report is conclusions on "Effect of Irregular Operation of the Unit Cost of Production of Bituminous Coal," with engineering studies for the Commission by C. E. Lesher and R. A. Walter. In this report the commission made plain that the cost of producing a ton of coal varies with the steadiness at which the mine is operated, because overhead and certain fixed charges continue even during periods of non-production.

Several statements have been filed with the commission by the Bituminous Operators' Special Committee, but no public comment was made by them on the report of the Coal Commission on civil liberties which was made public Sept. 10 and regarding which the United Mine Workers issued a statement criticizing the report as reading "very much like a well-prepared brief in behalf of the non-union bituminous coal operators of West Virginia and northeastern Kentucky."

A statement in behalf of the National Retail Coal Merchants' Association was filed with the Coal Commission Sept. 13 in which criticism of Governor Pinchot's settlement of the anthracite suspension was voiced. The retail dealers charged the Governor with having disregarded several essential considerations and termed the settlement a victory for "arrogant organized labor." Arbitration was relegated to the scrap heap, the statement says, charging that the Pennsylvania executive sought peace at any price and that the retailer cannot bear the burden of increased cost of anthracite resulting from the settlement. The Governor ignored, the statement alleges, the reports on margins of profit which the retailers had submitted to the United States Coal Commission.

While their term of office will expire Sept. 22, the members of the Coal Commission will remain available to President Coolidge for consultation and advice unofficially after that date.

Mercury Turbine Given Trial

The mercury turbine, being developed by the General Electric Co., which generates power from heated mercury and the theory of which has been discussed in the pages of *Power* several times, was on Sept. 7 given a trial under commercial load by the Hartford (Conn.) Electric Light Co., at the Dutch Point and South Meadow stations. About 600 kw. was delivered at the switchboard.

Canada Protests Against Diversion from Great Lakes

In the current issue of the *Electrical News*, Sir Adams Beck, chairman of the Hydro-Electric Power Commission of Ontario, protests against the amount of water being diverted from the Great Lakes by the Chicago Sanitary District. He states that there is an arbitrary and unauthorized diversion of sometimes as much as 10,000 cu.ft.-sec. from international waters by the Sanitary District and that Canada's resources are sacrificed by this illegal diversion, whereas Chicago has a right, as far as independent sanction by the United States is concerned, to divert only 4,167 cu.ft. of water per second.

This water is used for diluting the sewerage of the City of Chicago and of other places of the Sanitary District and is also employed for the development of hydro-electric energy in four relatively small plants which supply light and power for municipal purposes. Plans have been laid and some work done on an enlargement of this system to provide, via the Illinois River, a deep waterway from the Great Lakes to the Mississippi.

This would make available considerable additional power developments at the locks. However, as the Sanitary District does not appear to have a very strong case in the face of Canada's protest, an adverse decision would greatly curtail the output of the proposed power developments.

The Great Lakes-St. Lawrence Tidewater Association is also formulating plans, for getting action from the coming session of Congress for the development of the waterway from the Great

Lakes through the St. Lawrence, which are linked with the problems in Ontario and the New England States.

Waste of Coal in Mining in Bituminous Fields

The Coal Commission has issued another preliminary chapter of its report, "Amount and Nature of Losses in Mining Bituminous Coal in the Eastern United States."

The principal causes of losses were found to be coal left on the roof and bottom, coal lost in room entry and panel pillars, coal lost in oil and gas well pillars, coal lost under buildings, railroads and boundaries, coal lost in handling and preparation—underground and surface, coal lost by rolls, thin or dirty areas and streams.

The loss of coal based on production in 1921 as avoidable was 19.4 per cent and as unavoidable as 15.3 per cent. The total loss in tons was 196,168,000, avoidable being 109,605,000 and unavoidable 36,563,000. These avoidable losses are enumerated and credited principally to improper engineering or its lack, and carelessness.

Ferris Amendment to the New York State Constitution Meets Opposition

Nineteen Men Characterize the Amendment as Lumber and Water-Power Grab

THE Ferris amendment to the New York State Constitution permitting the use of not to exceed 3 per cent of the forest preserve for the building of transmission lines and power stations in connection with hydro-electric development is in serious danger of defeat when it goes to the people for approval at the general election in November.

This amendment to the constitution is considered to be of vital importance if St. Lawrence river power is to be developed and economically distributed in the territory of the capital district and the cities further south. As the matter now stands, no timber can be cut on the forest preserve, which would mean that the only way power from the St. Lawrence could be transmitted to the central and southern part of the state would be to carry it around the Adirondacks instead of by a direct route from the river to its destination.

The amendment has passed two successive legislatures as a bi-partisan measure and was drafted to coincide both with the Esch law of the United States and the Robinson law of New York State regulating the development and lease of state-owned water power. New York State has now reached a tentative working agreement with federal authorities over the question of state sovereignty of water power and, when certain incongruities between the Esch law and the Robinson law are clarified, will be in position to bring about speedy development of state-owned water power either through state or private agencies.

The Ferris amendment fits into the general scheme of development of state-owned power, and its passage is deemed absolutely essential if any consistent attempt is to be made to develop and distribute St. Lawrence power. Its lack of approval will mean the setting back for a period of from two to four years the fulfillment of a complete ultimate plan for the development and distribution of state-owned power for the reason that the legislature would have to start all over again. Constitutional amendments must be passed by two successive legislatures under two different administrations, which means, if the proposed amendment be defeated, that the legislature of 1924 and the legislature of 1925 could pass another amendment upon the subject which could be submitted to the people in that year.

It is said that not only will the defeat of the Ferris amendment set back the adoption of any definite ultimate program of power development under state supervision, but it is also likely to prejudice the position of the state in further negotiations with the Federal Power Commission.

Nineteen men, prominently connected with public and private interests in the Adirondacks, have published a booklet, "The Adirondack Raid," addressed to the voters of the state of New York, in which they voice a vigorous opposition to the amendment.

Smoke Ordinance Committee Appointed by the A.S.M.E.

The exigencies of the War, and later the periodic fuel disturbances which have necessitated the substitution of bituminous for anthracite coal in many industries and communities, together with the natural hesitation of the local officials in enforcing the smoke ordinances where such have existed, have led the Fuels Divisions of the A.S.M.E. to consider the formulation of an ordinance that may serve as a model or basis for smoke ordinances, for communities wishing to incorporate such a regulation into their laws. This model will serve as a basis for smoke ordinances, in the same way that the boiler code does for laws governing the installation of boilers.

The following men have signified their acceptance of an invitation to serve on this smoke ordinance committee: O. P. Hood, chief mechanical engineer, U. S. Bureau of Mines, Washington, D. C.; Henry Kreisinger, Combustion Engineering Corp., New York City; P. J. Dougherty, International Heater Co., Utica, N. Y.; Lloyd R. Stowe, Laclede-Christy Clay Products Co., St. Louis, Mo.; Everett Lee Millard, President, Chicago Suburban Gas & Electric Co., North Shore Gas Co., and American Civic Association, Chicago, Ill.; Osborn Monnett, Consulting Engineer, Chicago, Ill.; Dean Harry Bertine Meller, School of Mines, Pittsburgh University, Chief of Bureau of Smoke Regulation, Pittsburgh, Pa.

American Machinery Exports to Japan Show Increase

There has been a reversal of the positions occupied by the British and American manufacturers in Japan since 1913 as shown through an analysis of the figures given in the Japanese Customs Statistics, by the Department of Commerce.

In the earlier years the British controlled the market, but in the first part of 1915, owing to the war demands on British manufacturers, this business fell to a negligible quantity, while the American participation took a sharp upward trend. The point of especial interest is that in the post-war years the British have been unable to regain their former supremacy. On the other hand, American metal and woodworking machinery gained in favor consistently to 1920.

In 1913 the dominant position in the imports of each class of machinery into Japan was as follows:

BRITISH	AMERICAN
Steam engines, boilers, and fuel economizers; steam and water turbines; gas, petroleum, and hot air engines; pumping machinery; cranes; metal or woodworking machinery; paper-making machinery; power hammers; spinning, weaving, and tissue-finishing machinery; capstans, etc.; hydraulic presses; blocks and chain blocks.	Knitting machinery; gas compressors; blowing machines; all other machinery.

This comparison shows very clearly that the British held the control in the majority of items, their percentage to the total being 48.4, as against the American percentage of 8.7. By 1920 the situation had altered until the British percentage was only 20.6, compared with the increased American percentage of 51.4, and the specific classes of machinery were as follows:

BRITISH	AMERICAN
Steam engines; gas, petroleum and hot-air engines; spinning, weaving, and tissue-finishing machinery; fuel economizers.	Steam turbines and boilers; water turbines; pumping machinery; cranes; metal or woodworking machinery; paper-making machinery; knitting machinery; capstans, etc.; gas compressors; blowing machines; hydraulic presses; pneumatic tools; all other machinery.

The United States practically controls the ice-making machinery business, and only in 1913 did the British have even a "look-in" on this business. In 1920 it happens that the Japanese statistics do not show any imports of

ice-making machinery, although the American export figures show that $1,428,598 worth of refrigerating machinery (including ice-making) was billed to Japan.

Like the rest of the world Japan suffered from the general unrest following the war, and 1922 was quite adverse owing to the fact that imports exceeded exports, and the invisible exports diminished. Many of the new industries that purchased machinery and supplies from us have found it unprofitable to operate under present conditions and have either failed entirely or closed down. This process of elimination has been costly and has thrown on the Japanese market a certain amount of fairly new, used machinery which must be disposed of before fresh imports are sought.

But notwithstanding all these factors, it must be recognized that the value of this business will probably never drop to its low level as indicated by the five year average for 1909 to 1914 inclusive, of 12,940,357 yen, which average compares with a total of 82,762,000 yen in 1921 alone. Even taking the total sum of the five years' business it amounted to only 64,701,787 yen—less than the 1921 total.

Edison Companies Hold Record Convention

More than four hundred attended the forty-second convention of the Association of Edison Illuminating Companies at Dixville Notch, N. H., Sept. 17-22, this being by far the largest convention the association has held. The tone of the entire meeting indicated a realization of the immense development taking place within the industry and of the greater demands that are confronting it.

In his presidential address Matthew S. Sloan pointed to the stability of the financing of public utilities, particularly light and power companies. The light and power industry has developed to such a sound state that it can procure funds at less cost than most ordinary industrial enterprises. A word of advice was uttered by President Sloan, when he pointed to the large amount of industrial power load being taken by power companies. He called attention to the fact that great blocks of power load from large industrial concerns meant that central-station output and revenues would more and more depend on the business cycles and that central-station executives must study the cycles of business behavior and plan their developments accordingly. The speaker emphasized the stability inherent in a policy of customer ownership and urged that it become a universally accepted business policy in the central station industry.

The Prime Movers Committee report pointed to a definite advance in turbine practice as indicted by the fact that base-load machines are used more than 84 per cent of the time, as compared with the 78 per cent of last year's report. The committee included a discussion on higher steam pressures, summarizing its conclusions as follows: "At present we are not justified in considering a temperature much above 700 deg. F., but we may consider with more or less equanimity any pressure thus far suggested."

At Wednesday's session a discussion on reserve capacity in various parts of the system served to emphasize the already known fact that conclusive data or statistics for any generalization on this subject have never been developed.

J. W. Rupert Receives Prize

The first prize, given for the best answers to 45 questions asked by the Educational Committee of the N.A.S.E., was awarded to Judson W. Rupert at the Annual Convention of the N.A.S.E.

JUDSON W. RUPERT

held in Buffalo recently. The questions were published a short time ago in the *National Engineer*, and were answered by many contestants. Mr. Rupert, who is a prominent engineer belonging to No. 20, N.A.S.E., Bloomfield, N. J., received a rating of 96.5.

Old Hickory Powder Plant Receivers to Continue Sales

The Nashville Industrial Corporation announces that all sale contracts made by that corporation and now existing, will be taken over and consummated by the receivers, who will operate as Old Hickory Powder Plant Receivers.

Suit has been entered by the government against the Nashville Industrial Corp. in the Federal Court of the Middle District of Tennessee, asking that the contract held by that corporation with the government covering the sale of Old Hickory Plant be rescinded. The government alleges fraud in the original sale of the plant. By stipulation it was agreed that a receivership of the property would not be opposed by either side, and accordingly Judge Core of the court mentioned appointed B. P. Morse and W. P. Smith, joint receivers and issued instructions that the business should be carried on as usual, that sales of both realty and personalty shall be made and all activities instituted by the corporation shall continue under direction of the court.

Obituary

William F. Merrill, founder and president of Underwriters' Laboratories, Inc., died on Sept. 17 at the Presbyterian Hospital, Chicago. He was born in Warsaw, N. Y., in 1868, graduated from the Massachusetts Institute of Technology in 1889 and shortly thereafter went to Chicago for service in fire prevention work, finally organizing the Underwriters' Laboratories there. When the subject of an electrical code was being agitated, he served as one of the principal factors in bringing together the various interests which adopted and sponsored the National Electrical Code.

Society Affairs

The Mid-Continent Section of the **A.S.M.E.** will be held in connection with the International Petroleum Exposition and Congress at Tulsa, Okla., **Oct. 11.**

The **A.S.M.E.** at its **Regional Meeting at Chattanooga, Tenn., Oct. 23-24** will hold sessions on welding, power and fuels, and management. Papers of immediate interest to *Power* readers are the following: "Welding Pressure Vessels and Pipe Lines," by S. W. Miller; "Power Development of the Southern Appalachian Slope," by Prof. J. A. Switzer and W. R. Woolrich; "Use of Pulverized Fuels in Small Industrial Plants," by R. H. Lowndes.

The **National Safety Council** will have on its program at its Twelfth Annual Safety Congress, to be held at the Statler Hotel, Buffalo, **Oct. 1-5**, the following papers which will be of interest to readers of *Power:*

"Powdered Coal Hazards," by H. G. Jacobsen, manager of the bureau of accident prevention and insurance, Portland Cement Association; "Accidents in the Ice and Refrigeration Industry," by O. F. Wilkinson, City Ice & Fuel Co., Cleveland, Ohio; "The Prevention of Accidents During Construction of Gas and Electric Plants," by J. A. P. Crisfield, vice-president, United Gas Improvement Contracting Co., Philadelphia.

Personal Mention

Peter L. van Everdingen has been appointed chief engineer of the new high school at Omaha, Neb.

H. G. Kinder has been named manager of the arch and specialty department of the Brady Conveyors Corp., 20 West Jackson Boulevard, Chicago, Illinois.

Benjamin T. Allen, chief engineer of the Harrisburgh Foundry and Machine Works, acted for the City of Harrisburg in the acceptance tests of engines, turbines, pumps and boilers for the North Street pumping plant and also for the city filtration plant on the island.

I. F. Baker, the manager for Japan of the Westinghouse Electric International Co., and **C. A. Johnson**, general engineer, **R. D. McManigal**, railway engineer, and **John J. Mylin**, service representative, all in the earthquake zone, are reported safe. These men have been for some time in Japan supervising installations of big electrical projects for Japanese firms for the Westinghouse Company.

Business Notes

The Celite Products Co., Monadnock Bldg., San Francisco, Calif., announces that **O. C. Krotz** has been appointed district manager in charge of its Denver office in the Symes Bldg., Denver, Colo.

Stone & Webster, Inc., of Boston, have opened an office in Cleveland, Ohio, at 1431 Leader Building. The office is in charge of J. R. Hammond as district manager of construction and engineering.

The Geo. T. Ladd Co., manufacturer of water-tube boilers, announces that C. M. Decker, Philadelphia representative, has moved his office from the Land Title Bldg., to 504 Franklin Bank Bldg., Philadelphia, Pa.

The Graver Corporation, East Chicago, Ill., manufacturer of water softeners and filters, announces the following changes in its offices: The Water Works Supply Co., 536 Call Bldg., San Francisco, Cal., will be their representative in California, the Los Angeles offices having been discontinued; H. K. Mead, 409 Board of Trade Bldg., Portland, Ore., will take care of the business in the states of Washington and Oregon, the Seattle office having been discontinued; L. C. Holmes, 918 Buchanan St., N. W. Washington, D. C. will represent the firm in that district, the Philadelphia office also being discontinued.

Trade Catalogs

Filters, Water—Craver Corp., East Chicago, Ind. Bulletin No. 501 shows the construction and operation of horizontal pressure-type water filters. Illustrations and tables of capacities, dimensions and weights add to its usefulness.

Filters, Water — Permutit Co., 440 Fourth Ave., New York City. Bulletin No. 105 goes into the subject of water softening and filtration, with tables of dimensions for vertical and horizontal pressure and gravity filters and is well illustrated.

Coming Conventions

American Electric Railway Engineering Association, James W. Welsh, 8 West 40th St., New York City. Annual Convention at Young's Pier, Atlantic City, Oct. 8-12.

The American Electrochemical Society. Colin G. Fink, Columbia University, New York City, Convention at Dayton, Ohio, Sept. 27-29.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

The American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meetings, Richmond, Va., Oct. 17-20.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6. Regional meeting at Chattanooga, Tenn., Oct., 23-24.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

American Welding Society. M. M. Kelly, 33 West 39th St., New York City. Fall Meeting, Pittsburgh, Pa., Oct. 24-26.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Association of Railway Electrical Engineers. Jos. A. Andreuccetti, Room 413, Chicago & Northwestern R.R. Station, Chicago, Ill. Thirteenth Annual Convention at Hotel La Salle, Chicago, Ill., Nov. 6-9.

Electric Power Club, S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

Empire State Gas & Electric Association, Charles H. B. Chapin, Grand Central Terminal Bldg., New York City. Meeting at Lake Placid, N. Y., Oct. 8-9.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

Indiana Electric Light Association, T. Donahue, Northern Indiana Gas & Electric Co., Lafayette, Ind. Meeting at French Lick Springs, Ind., Sept. 26-29.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

Switches, Noark Service — Johns-Pratt Co., Hartford, Conn. Catalog No. 53 covers the construction, connections and circuit arrangements for these single-phase or direct current switches.

Regulator, Mercon—D. H. Skeen & Co., 407 South Dearborn St., Chicago, Ill. Leaflet describing this mercury-controlled excess-pressure regulator for steam- or motor-driven boiler feed pumps is illustrated with drawings showing operation and construction.

Machinery, Power Plant—Mesta Machine Co., Pittsburgh, Pa. Bulletin C is a small-sized book filled principally with photos of installations of gas and steam, unaflow, piston and Corliss valve, reversing and blowing engines and barometric condensers and vacuum pumps.

Engines, Diesel—Worthington Pump and Machinery Corp., 115 Broadway, New York City. Pamphlet on "Application of Internal Combustion Engines to Water Works Service." The papers contained in the pamphlet are reprints from the Journal of the New England Water Works Association.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Sept. 10, 1923	Sept. 17 1923
Pool 1,	New York	$3.00@3.50	$3.00@3.50
Smokeless,	Columbus	2.75@3.25	2.75@3.25
Clearfield,	Boston	1.85@2.50	1.80@2.50
Somerset,	Boston	2.25@2.75	2.00@2.75
Kanawha,	Columbus	1.75@2.10	1.75@2.10
Hocking,	Columbus	1.85@2.00	1.85@2.00
Pittsburgh No. 8	Cleveland	2.05@2.15	2.00@2.10
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.10@2.35	2.10@2.35
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.85@2.10	1.85@2.10
S. E. Ky.,	Louisville	1.75@2.25	1.75@2.25
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Sept. 20, light oil, tank car lots, 28@34 deg. Baumé, 4c. per gal., 36@40 deg. 4¼c. per gal., f.o.b. Bayonne, N. J.

Chicago — Sept. 17, 24@26 deg. Baumé, $1.82@2.07 per bbl.; 32@36 deg., $2.02@2.07 per bbl., tanks cars.

St. Louis—Sept. 11, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.90; 28@30 deg., $1.95; 32@36 deg., gas oil, 4¼c. per gal.; 36@40 deg., distillate, 4¾@5c. per gal.

Pittsburgh—Sept. 14, f.o.b. local refinery, 30@34 deg., fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5¼c.; 34 deg., neutral 7c.

Dallas—Sept. 14, f.o.b. local refinery, 26@30 deg., $1.35 per bbl.

Cincinnati—Sept. 4, tank-car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¼c. per gal.; 30@32 deg., 4¼c.; 38@42 deg., distillate, 5¾c.

Philadelphia—Sept. 14, 26@28 deg., $1.68@1.722 per bbl.; 16@20 deg., $1.64 @1.68; 14@16 deg., $1.57@1.612.

New Plant Construction

PROPOSED WORK

Ark., Murfreesboro—The Henrici Lowry Eng. Co., Commerce Bldg., Kansas City, Mo., is preparing plans for the construction of a plant for hydraulic mining, including crusher, quarry, engines, boilers and high pressure pump, here. Owner's name withheld.

Ark., North Little Rock (Little Rock P. O.)—F. Hines, Dir. of the United States Veterans' Bureau, 2306 Munitions Bldg., Wash., D. C., will receive bids until Oct. 16 for additional buildings to United States Veterans' Hospital 78, including heating equipment, etc. Noted July 17.

Calif., Helm—The Stimson Irrigation Dist. received bids for motors, pumps, etc., in connection with irrigation improvements as follows: (1) ten to twenty vertical shaft induction motors, 60 cycle, 1,200 r.p.m., 3 phase, 20 and 25 hp.; (2) three to six horizontal shaft motors, 860 r.p.m., 20 or 25 hp.; Genl. Electric Co., Rialto Bldg., San Francisco, (1a) $355, (1b) $417, (2a) $325, (2b) $362; Westinghouse Electric Co., First Natl. Bank Bldg., San Francisco, (1a) $359.85, (1b) $420, (2a) $421, (2b) $487; Fairbanks-Morse Co., Spear and Harrison Sts., San Francisco, (1a) $376, (1b) $433, (2a) $377, (2b) $415; Allis-Chalmers Mfg. Co., Rialto Bldg., San Francisco, (1a) $403, (1b) $341, (2a) $368, (2b) $319; United States Electric Co., 710 Polk St., San Francisco, (1a) $289, (1b) $375, (2a) $245, (2b) $300; Wagner Electric Corp., 159 New Montgomery St., San Francisco, (1a) $344, (1b) $377, (2a) $301, (2b) $363; (3) three to six deep well turbine pumps, 60 ft. column, 20 ft. suction, lift 35 to 50 ft., 2 to 2.5 sec.ft.; (4) ten to fourteen deep well turbine pumps, 60 ft. column, 20 ft. suction, 2 to 3 sec.ft., 35 to 50 ft. lift; Western Well Wks., San Jose, (4) $938.60 per pump; Layne & Bowler, San Jose, (3a) $956, (3b) $794, (3c) $731; Byron-Jackson Mfg Co., 55 New Montgomery St., San Francisco, (4) $935 each; Stirling Iron Wks., Stockton, (4a) $815, (4b) $765, (4c) $155, (4d) $1,000; Kimball Electric Co., Los Angeles, (6 pumps), (3a) $6,324, (3b) $4,490, (3c) $5,844, (3d) $4,110; Peerless Pump Co., Los Angeles, (4) $760 each; Worthington Co., Sharon Bldg., San Francisco, (a) $2,200, (b) $1,792, (c) $1,975, (d) $2,040; (6) construction of pump houses; Jolly & Jolly, Fresno, $483 each, fourteen to twenty houses; California Corrugated Culvert Co., Berkeley, fourteen for (a) $3,385, (b) $3,104, (c) $1,709, (d) $1,391; Western Well Wks., San Jose, $132.50; P. Johnson, Kingsburg, $620 each. Noted Aug. 21.

Calif., Livermore — The United States Veterans' Bureau is having revised plans prepared for the construction of a hospital, 250 bed capacity, here. Equipment detail not reported.

Calif., Los Angeles—The Pacific Southwest Trust & Savings Bank, 565 South Spring St., plans to build a 75 x 100 ft. store and office building on 8th and Olive Sts. Cost will exceed $750,000. Engineer or architect not selected.

Calif., Los Angeles—St. Vincent's Hospital, 1151 Sunset Blvd., is having plans prepared for the construction of a hospital, including main building, also boiler and laundry plant on Sunset Blvd. and Beaudry St. Cost will exceed $750,000. J. C. Austin, Detwiler Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., Marysville—The city, J. O. Wanzer, Mgr., will receive bids for furnishing and installing one vertical sewage 8 in. sump pump. Noted Aug 21.

Calif., Oakland—The County of Alameda is having plans prepared for the construction of an administration building for the county hospital. Cost between $600,000 and $700,000. H. H. Meyers, Kohl Bldg., San Francisco, Archt. Equipment detail not reported.

Calif., San Francisco—C. A. Meussdorffer, Archt., Humboldt Bank Bldg., is receiving bids for the construction of a 10 story apartment house on Washington St. near Gough St. for Two Thousand and Six Washington St., Inc., c/o Archt. Estimated cost $500,000. Equipment detail not reported. Noted July 3.

Calif., San Francisco—The Office of the United States Engineer, 85 2nd St., will receive bids until Oct. 8 for furnishing and delivering 20 in. booster pump with spare parts, including one impeller, one complete casing, 2 liner engine side, 2 wearing ring engine side, 2 wearing suction side and one suction mouthpiece, for use in connection with the discharge line of a 20 in. pipe line dredge.

Calif., San Francisco—The Pacific Telephone & Telegraph Co., 333 Grant Ave., is having preliminary plans prepared for the construction of an office and telephone exchange building on Bush St. between Grant Ave. and Karny St. Estimated cost $1,000,000. E. V. Cobby, 333 Grant Ave., San Francisco, Archt.

Calif., San Francisco — The Western Vacuum Ice Co., c/o E. W. Crellin, 235 Montgomery St., is having plans prepared for the construction of a 1 story, 65 x 110 ft. ice manufacturing plant and a 35 x 75 ft. warehouse near Brannan and 8th Sts. H. H. Meyers, Kohl Bldg., San Francisco, Archt.

Colo., Denver—The Norman Apartments, Inc., 915 Central Savings Bank Bldg., is having plans prepared for the construction of a 6 story, 150 x 150 ft. apartment house, including two elevators, etc., on Downing and Bayard Sts. Estimated cost $500,000. W. N. Bowman, Central Savings Bank Bldg., Archt.

Conn., Hartford—J. Fox & Co., Inc., 960-980 Main St., plans to build a 6 story department store on Main and Talcot Sts. Estimated cost $500,000. Engineer or architect not selected.

Conn., Hartford—G. F. Heublein, Inc., 45 High St., plans to build a 3 story, 134 x 150 ft. theater on Church St.; also a 10 story, 60 x 165 ft. office building on Pratt and Trumbull Sts. Estimated cost $500,000 each. Engineer or architect not selected.

Fla., Palm Beach—D. P. Robinson & Co. and associates, 125 East 46th St., New York, are having plans prepared for the construction of a 6 story apartment on Ocean Blvd. Estimated cost $1,000,000. E. McCullough, 125 East 46th St., New York, Engr. J. E. R. Carpenter, 598 Madison Ave., New York, Archt. Equipment detail not reported.

Fla., Tampa—The Guarantee Title Bldg. is having plans prepared for the construction of a 25 story office building. Estimated cost $2,000,000. N. W. Gillen, Citizens Bank Bldg., Tampa, Engr. M. L. Elliott, 2516 Michigan Ave., Tampa, Archt. Equipment detail not reported.

Idaho, Lewiston—The city, J. R. Turnbull, Controller, will receive bids until Oct. 10 (change of date) for waterworks improvements, including hydrants and valves; c.i. pipe; five motor driven, horizontal, centrifugal pumps consisting of three low service pumps, 1,600, 2,10 and 2,800 g.p.m., one high service pump, 2,100 g.p.m., one filter wash pump, 500 g.p.m., also starters, starting panels and miscellaneous electrical equipment; complete equipment for four 1,500,000 g.p.d. filter units; pipe laying; one 3,600,000 gal. and one 4,000,000 gal. reservoir; construction of purification plant, filter basins, mixing chamber, settling basins, filtered water reservoir and new intake lines, moving and resetting present pumps and installing new pumps. Burns & McDonnell Eng. Co., 402 Interstate Bldg., Kansas City, Mo., Engrs. Noted Aug. 28.

Ill., Chicago—N. E. Feiwell is having plans prepared for the construction of an 8 story, 100 x 150 ft. apartment hotel on Granville and Winthrop Sts. Estimated cost $1,000,000. Loewenberg & Loewenberg, 111 West Monroe St., Archts. Equipment detail not reported.

Ill., McLeansboro—The city voted $31,510 bonds for waterworks improvements, including a 400,000 gal. filter, pipe, etc., $18,000; engine and generator, $13,500. W. A. Fuller Co., Railway Exch. Bldg., St. Louis, Mo., Engrs. Noted Aug. 7.

Ia., Dubuque—The city, c/o O. E. Carr, Mgr., is receiving bids for equipment, including switchboard, complete transformers and heating system, for Eagle Pumping station. Mead & Seastone, Journal Bldg., Madison, Wis., Engrs. Noted May 15.

Ia., Washington—The city voted $80,000 bonds for the construction of a pumping plant, elevated tank and additional wells. A. L. Mullergren, 555 Gates Bldg., Kansas City, Mo., Engr. Noted Aug. 28.

Ky., Louisville—The Louisville Ry. Co., Traction Bldg., is having plans prepared for the construction of a station and office building on 2nd and Liberty Sts. Estimated cost $1,000,000. Joseph & Joseph, Francis Bldg., Louisville, Archts. Equipment detail not reported. Noted June 5.

Ky., Louisville—D. X. Murphy & Bro., Archts., Louisville Trust Bldg., will receive bids until Oct. 9 (change of date) for the construction of a 5 story, 50 x 388 ft. infirmary with 52 x 115 ft. wings, also a 4 story, 42 x 215 ft. sisters' home on Eastern Parkway for St. Joseph's Infirmary, 4th St. Estimated cost $1,000,000. Equipment detail not reported. Noted Sept. 4.

Ky., Lyndon — The Kentucky Children's Home Society, 1086 Baxter St., Louisville, is having plans prepared for the construction of a children's home, including hospital, boiler house, etc., here. Estimated cost $150,000. Nevin, Wischmeyer & Morgan, Starks Bldg., Louisville, Archt. Equipment detail not reported.

La., Carville—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until Oct. 16 for mechanical equipment, including heating, sewage disposal, refrigeration, etc., for additional buildings; construction of power house with equipment; furnishing and installing one engine, generator, etc., in the Natl. Home for Lepers, here.

Mich., Flint—The Bd. Educ. is having plans prepared for the construction of a 3 story, 200 x 369 ft. building for the Second Intermediate School, including steam heating boilers and equipment. Estimated cost $1,000,000. Malcolmson & Higginbotham, Industrial Bank Bldg., Detroit, Archts.

Mich., Marquette—The city plans an election in December to vote $100,000 bonds for the construction of a hydro-electric power plant, including water wheels, generators, auxiliary boilers, etc., on the Dead River. Orbison & Orbison, 812 College Ave., Appleton, Wis., Engrs.

Mich., South Haven — The Edgemere Hotel Corp., c/o Leickenko & Esser, Archts., 38 South Dearborn St., Chicago, is having plans prepared for the construction of a 3 and 6 story, 130 x 275 ft. hotel and store building, including steam heating system, on North Shore Drive, here. Estimated cost $750,000.

Minn., Litchfield—The village, M. Mortenson, Recorder, will receive bids until Sept. 28 for the construction of a power house; 72 x 150 ft. chimney; 500 kva. steam engine driven generating unit, switchboard, etc.; boiler plant and piping, including 250 hp. water tube boiler and stoker; water softening plant for boiler feed, 24,000 g.p.d. capacity; wells and piping. Alternate bids on partial or complete power house and on different types of chimney construction. Estimated cost $90,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, and E. D. Jackson, 403 Endicott Bldg., St. Paul, Engrs. Noted June 19.

Minn., Little Falls — The Pike Rapids Power Co. has been granted a license by the Federal power commission for the construction and operation of a hydro-electric power plant, including a 45 ft. dam to produce about 10,000 kw. of primary power and the same of secondary, at Pike Rapids on the Mississippi River, five miles from here.

Minn., Winona—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, received bids for the construction of a 3 story, 200 x 210 ft. main building, including power plant, for the State Teachers' College, here from the L. Fleisher Co., 505 Plymouth Bldg., Minneapolis, $470,000; S. M. Klarquist Sons Co., 745 Security Bldg., Minneapolis, $473,407; J. A. McDonald Constr. Co., 750 Builders' Exch., Minneapolis, $479,709. Bids were rejected and low bidders were asked to refigure. Steam heating system will be installed. Noted Sept. 4.

Mo., Caruthersville — The Arkansas-Missouri Power Co. is having plans prepared and will soon award the contract for transmission lines from here to Blytheville, Ark., Hayti, Kennett and Rector, distribution lines here, also in Blytheville and Kennett, and a 600 kw. Diesel unit in plant, here. Estimated cost $308,400. Private plans.

Mo., Gallatin—The city, C. W. Billings, Mgr., is in the market for a 250 hp. motor driven engine for electric light plant.

Mo., Mountain Grove — The city voted $35,000 bonds for the construction of an electric light plant and distribution lines. Private plans. Noted Sept. 4.

Mo., Norborne — The city will hold an election Oct. 2 to vote on bonds as follows: $57,178.63 for water plant, distribution mains and water softener; $39,132.85 for sewers and septic tank; $33,427.53 for lighting plants and lines. R. R. McBride, Kansas City, Engr. Noted Aug. 21.

Mo., Republic — The city voted $35,000 bonds for the coenstruction of a power plant and transmission lines to various parts of the city. Noted Sept. 4.

Nev., Reno—F. H. Whitton, 369 Pine St., San Francisco, Constr. Mgr. of the Reno Hotel Co., is preparing preliminary plans for the construction of a 4 story hotel, here. Cost between $400,000 and $500,000.

N. J., Hawthorne—The borough will receive bids Sept. 28 for the construction of a pumping station, stand pipe and main. H. J. Harder, 129 Market St., Paterson, Engr.

N. J., Lavallette—The borough is having plans prepared for a well, pumping and distribution sysptem, including pumping equipment and c.i. pipe. Estimated cost $75,000. Sherman & Sleeper, 501 Cooper St., Camden, Engrs.

N. J., Park Ridge—The borough is having plans prepared for a water supply system. Bids will be received in January, 1924. Estimated cost $200,000. H. J. Harder, 129 Market St., Paterson, Engr.

N. J., Trenton—J. O. Hunt, Engr. and Archt., 219 East Hanover St., will receive bids until Oct. 9 for the construction of a 4 story building for the Young Woman's Christian Assn., 141 East Hanover St. Estimated cost $600,000. Equipment detail not reported. Noted Apr. 17.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, is having plans prepared for the construction of the James Madison High School, including steam heating system, on Bedford Ave. Estimated cost $2,140,000. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt.

N. Y., Niagara Falls—The International Paper Co., Buffalo Ave., is having plans prepared for the construction of a boiler house. Estimated cost $200,000. Private plans.

N. C., Fayetteville—The Directors of the Fayetteville Hotel Co. will receive bids until Oct. 8 for the construction of an 8 story hotel. Stiles & Dixon, Fayetteville, and W. G. Rogers, Trust Bldg., Charlotte, Archts. Equipment detail not reported. Noted Aug. 14.

N. C., Mooresville — The Cascade Mills, Inc., 306 North Main St., Lexington, A. F. Bruton, Pres., plans to install equipment, including a small power unit, in its factory, here. Lockwood, Greene & Co., Piedmont Bldg., Charlotte, Engr. and Archt.

Ohio, Cincinnati—The Amer. Druggists' Fire Insurance Co., 1004 Mercantile Library Bldg., is having plans prepared for the construction of a 10 story, 85 x 100 ft. office building on Walnut St. and Central Parkway. Estimated cost $600,000. J. G. Steinkamp & Bro., 1212 Mercantile Library Bldg., Archts. Equipment detail not reported.

Ohio, Cincinnati—A company represented by D. G. Ebersole, Pres., 4th and Main Sts., is having plans prepared for the construction of a 12 story, 91 x 110 ft. apartment house on 4th St. and Broadway. Estimated cost $1,200,000. H. Hake, Telephone Bldg., Cincinnati, Archt. Equipment detail not reported.

Ohio, Cincinnati—The Hotel Alms Co., Alms Pl., is having plans prepared for the construction of a 12 story hotel. Estimated cost $2,000,000. H. Stake, Telephone Bldg., Archt. Equipment detail not reported.

Ohio, Cleveland—The Bd. of County Comrs., c/o A. J. Hieber, Clk., Court House, is having plans prepared and will hold an election Nov. 6 to vote about $2,000,000 bonds for the construction of a 17 story courts building. J. H. Graham & Co., 8201 Cedar Ave., Cleveland, Archts. Equipment detail not reported.

Ohio, Cleveland — The Bd. of County Comrs., c/o A. J. Hieber, Clk., Court House, will receive bids until Sept. 26 for a refrigeration plant for the County Morgue.

Ohio, Cleveland — The Roman Catholic Diocese, J. F. Smith, 13824 Euclid Ave., administrator, plans to build a group of university buildings. Estimated cost $3,000,000.

Ohio, Dayton — The Lincoln Apartment Hotel Co., Reibold Bldg., H. F. Kumler, Pres., plans to build a 14 story, 79 x 132 ft. apartment house on 4th and Perry Sts. Estimated cost $2,000,000. Engineer or architect not selected.

Ohio, Toledo—The Harbauer Tomato Catsup Co., Dearborne Ave. along tracks of Terminal R.R., H. C. Koch, Mgr., is in the market for machinery and equipment for boiler room, engine room, power plant and cook room, to replace that which was destroyed by fire.

Okla., Cheyenne—The city is having plans prepared and will soon hold an election to vote $25,000 bonds for a waterworks system, including well, mains and pump. E. W. Baker, 1st Natl. Bank Bldg., Oklahoma, City, Engr.

Okla., Cyril—The city, M. M. Rowe, Clk., will receive bids until Sept. 28 for a deep well pump, 10 hp. motor, tank, tower and pipe lines. Estimated cost $31,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City Engrs. Noted Sept. 18.

Okla., Enid—The city, G. R. Reinhardt, Water Comr., is having preliminary estimates prepared for waterworks extension improvements, including obtaining an additional 5,000,000 g.p.d. water supply, storage reservoirs, electric motor driven pumping equipment, pipe lines, etc. B. F. Lewis, City Engr. J. D. Bomford & Co., Masonic Temple, Enid, Consult. Engrs.

Okla., Sayre—The city plans an election to vote $85,000 bonds for waterworks improvement, including sewers and power plant. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs.

Okla., Terlton — The city plans election Sept. 25 to vote $20,000 bonds for a waterworks system, including tower, well and pump. F. B. King, 409 West 11th St., Oklahoma City, Engr.

Pa., Meadville—The Odd Fellows Home Assn., W. C. Moritz, Secy., plans to build a 2 story hospital. Estimated cost $250,000. Engineer or architect not announced.

Pa., Phila.—The 13th & Locust Realty Co., c/o L. Rothschild, Archt., 215 South Broad St., will soon award the contract for the construction of a 12 story, 33 x 115 ft. apartment house on 13th and Locust Sts. Estimated cost $1,000,000. Equipment detail not reported.

Tenn., Knoxville—The city will hold an election Sept. 29 to vote $750,000 bonds for the construction of an auditorium and market house.

Tenn., Nashville—Marr & Holman, Stahlman Bldg., are preparing plans for the construction of a 12 story hotel on 8th Ave. and Chestnut St. Estimated cost $1,300,000. Owner's name withheld. Equipment detail not reported.

Tex., Fort Worth—The City Comn. will receive bids about Sept. 28 for equipment, including two 700 g.p.m. centrifugal pumps, motors, piping, accessories, etc., for Arlington Heights pumping station. Estimated cost $10,000. D. Lewis, City Engr. J. R. Hawley, Cotton Exchange Bldg., Fort Worth, Consult. Engr.

Tex., Kerrville—The city plans the construction of a new pumping unit and well. Estimated cost $15,000.

W. Va., Huntington—The Office of the United States Engineer is in the market for a deep well pump.

Wis., Fond du Lac—St. Agnes Hospital, c/o M. Marcella, 309 Division St., is having plans prepared for the construction of a 2 story, 60 x 120 ft. power house. Estimated cost $50,000. Schmidt, Garden & Martin, 104 Michigan Ave., Chicago, Archts. The owner is in the market for ash handling equipment, power machinery, etc. Noted June 5.

Wis., Green Bay — The city, F. Carter, Supt., is having plans prepared for replacing present steam boiler equipment in the municipal pumping station with gas engine and electric motor equipment, including new pumps, etc. Estimated cost $75,000. A. E. Kringle, City Hall, Engr.

Wis., Sheboygan — The Bd. of Public Wks., City Hall, C. M. Boley, Pres., is receiving bids for central heating plant, including boiler, piping and radiation, for the City Alm House. R. R. John, City Hall, Engr.

Ont., Ford—The Essex Border Utilities Comn. is having plans prepared for the construction of a filtration plant to serve five municipalities. Bids will be received about Nov. 1. Estimated cost $150,000. J. C. Keith, 300 Ouellette Ave., Windsor, Engr. The owner is in the market for materials and equipment.

CONTRACTS AWARDED

Ark., El Dorado—G. W. James will build a 4 story, 100 x 125 ft. hotel by day labor. Estimated cost $300,000. Equipment detail not reported.

Calif., Los Angeles—The Commercial Bldg. Co., 715 Junior Orpheum Bldg., awarded the contract for the construction of 1 and 13 story store, office and bank building on Hollywood Blvd. and McCadden St. to the Simpson Constr. Co., Bank of Italy Bldg., Los Angeles. Estimated cost $450,000. Equipment detail not reported.

Calif., Los Angeles—The Standard Oil Co., Higgins Bldg., awarded the contract for the construction of an 8 story office building on 10th and Hope Sts. to the Foundation Co., Higgins Bldg. Estimated cost $1,500,000. Equipment detail not reported. Noted May 29.

Calif., Modesto—The Modesto Irrigation Dist. awarded the contract for transformers and meters for 12 month period to the General Electric Co., Rialto Bldg., San Francisco, $31,872 and $10,046 respectively. Noted Aug. 21.

Colo., Denver—The Capitol Life Insurance Co., Colorado Theatre Bldg., awarded the general contract for the construction of one wing of 2 story, 160 x 250 ft. office building on Sherman St. and 16th Ave. to the F. J. Kirchof Constr. Co., 718 Lawrence St., Denver, $130,000. Total estimated cost $600,000. Contract for heating system, etc., has not been awarded. H. J. Manning, Majestic Bldg., Denver, Archt. Noted June 12.

Ill., Joliet—The Eagle Paper Co. awarded the contract for three 18 x 72 in. boilers to the Wickes Boiler Co., 512 North Water St., Saginaw, Mich., type E stokers to the Combustion Eng. Corp., 43 Bway., New York; fan and fan engine to the Clarage Fan Co., North and Porter Sts., Kalamazoo, Mich. The contract for engine-generator set has not been awarded. Cahill & Douglas, 217 West Water St., Milwaukee, Wis., Engrs. Noted July 24.

Ky., Louisville — The Kosairs Assn. awarded the contract for the construction of a 7 story temple, hotel, etc., on Broadway to C. A. Koerner & Co., 318 East Burnett St., Louisville, $700,000. The owner received bids for furnishing and installing heating and ventilating equipment from A. J. Anderson, 338 West Main St., Louisville, $51,000. Noted Sept. 18.

Ky., Louisville—The Office of the United States Engineer, P. O. Box 72, awarded the contract for one 75 hp. vertical 550 volt motor to the Westinghouse Electric & Mfg. Co., M. E. Taylor Bldg., Louisville, $1,738. Noted Sept. 11th.

Mich., Lansing—The Atlas Drop Forge Co., Mount Hope St., is building 2 story, 38 x 60 ft. boiler house, foundations for boilers and a stack, 225 ft. high, 10½ ft. diameter at top. H. G. Christman Co., Porter Apartments, Lansing, Engr. and Contractor.

Mich., Lansing—The Durant Motor Car Co. is building a 1 story, 36 x 42 ft. power plant, etc. H. G. Christman Co., Porter Apartments, Lansing, Engr. and Contractor.

Mich., Lansing—The Federal Drop Forge, South Washington St., is building a 1 story, 50 x 60 ft. heat treatment building. H. G. Christman Co., Porter Apartments, Engr. and Contractor.

Mich., Lansing—The Reo Motor Car Co., South Washington St., is building a 2 story, 48 x 48 ft. addition to boiler house on Washington Ave. H. G. Christman Co., Porter Apartments, Lansing, Engr. and Contrac

N. J., Montclair—The Montclair Ice Co. awarded the contract for the construction of a 1 story ice plant to the J. S. Carlson Co., Inc., Walnut St., Montclair. Estimated cost $100,000.

N. J., Pennington—The Borough Council awarded the contract for reconstruction of water plant, including electrically operated pumping plant, c.i. pipe, fire hydrants, etc., to the N. A. K. Bugbee Co., 205 East Hanover St., Trenton, $29,306.50. Noted July 24.

N. Y., Brooklyn—The Kraslow Bldg. Co., Inc., c/o Shampan & Shampan, Archts., 188 Montague St., will build a 14 story, 125 x 215 ft. apartment house on Ocean Ave. by day labor. Estimated cost $1,500,000. Equipment detail not reported.

N. Y., New York—The Brown Constr. Co., c/o G. F. Pelham, Engr. and Archt., 200 West 72nd St., will build a 15 story, 82 x 83 ft. apartment house at 165 West 79th St. by day labor. Estimated cost $600,000. Equipment detail not reported.

Ore., Jennings Lodge—The Oak Lodge Water Dist. awarded the contract for the construction of a waterworks system, including pipe, reservoir and pumps to the Parker-Schram Co., Couch Bldg., Portland. $177,000. Noted July 31.

Tenn., Memphis—The Cotton Exchange awarded the contract for the construction of a 12 story office building on South Front and Union Sts. to the Kaucher-Hodges Co., Exch. Bldg., Memphis. Estimated cost $600,000. Equipment detail not reported.

Wash., Olympia—The Sisters of Charity awarded the contract for the construction of a 5 story, 175 x 240 ft. hospital to A. W. Quist & Co., Hoge Bldg., Seattle. Estimated cost $310,000. Steam heating system, to use fuel oil, will be installed.

Wis., Green Bay—St. Joseph's Orphanage, Route 6, awarded the contract for the construction of a 2 and 3 story, 42 x 150 ft. laundry, boiler house and hospital to Pinchard Bros., 605 St. George St., Green Bay. Estimated cost $150,000. Noted Sept. 4.

Wis., Madison — The Hotel Wisconsin Realty Co., c/o W. Schroeder, 86 Michigan St., Milwaukee, awarded the contract for steam heating plant, including boilers, radiation, piping, etc., in new $1,000,000 hotel, here, to the P. E. Mueller Co., 323 East Wilson St., Madison. Estimated cost $90,000.

Wis., Madison—The Piper Bros. Co., 31 North Pinckney St., awarded the contract for the construction of a 10 story, 44 x 120 ft. hotel on Pinckney St. to the Bailey-Kasson Co., 139 North Clark St., Chicago. Estimated cost $300,000. Steam heating system, piping, boilers and radiation system will be installed. Noted Sept. 18.